California Residential Alternative Calculation Method

Reference Manual

November 15, 2012

DRAFT

For instructions on how to submit written comments about this document to the California Energy Commission, please see the Notice of Staff Workshop:
www.energy.ca.gov/title24/2013standards/implementation/documents/2012-11-20_workshop/2012-11-20_workshop_notice_res_acm_manual.pdf

Contents

Figures

Tables

1 Introduction

1.1 Purpose

This manual documents the rules used for modeling residential buildings for Performance Compliance under the 2013 California Energy Efficiency Standards for Low-Rise Residential Buildings. Documentation of detailed calculation algorithms is contained in the companion volume:

California Residential Alternative Calculation Method - Algorithms

1.2 Other sections TBD

2 The Proposed Design and Standard Design

2.1 Overview

This chapter describes how the Proposed Design is modeled and how the Standard Design is established.

2.1.1 *Proposed Design*

The building configuration is defined by the user through entries for floor areas, wall areas, roof and ceiling areas, fenestration areas, and door areas. Each is entered along with performance characteristics such as U-factors, SHGC, thermal mass, etc. Information about the orientation and tilt is required for walls, fenestration and other elements. The user entries for all of these building elements shall be consistent with the actual building design and configuration. If the Compliance Software models the specific geometry of the building by using a coordinate system or graphic entry technique, the data generated shall be consistent with the actual building design and configuration.

2.1.2 *Standard Design*

The Standard Design building has the same floor area, volume, and configuration as the Proposed Design, except that wall and window areas are distributed equally between the four main compass points, North, East, South and West. For alterations, the Standard Design shall have the same wall and fenestration areas and orientations as the proposed building. The details are described below.

The space conditioning energy budget for the residential Standards is the energy that would be used by a building similar to the Proposed Design if the proposed building met the requirements of the prescriptive Standards. The process of generating the Standard Design is performed automatically by the Compliance Software, based on fixed and restricted inputs and assumptions. The process of custom budget generation shall not be accessible to program users for modification when the program is used for compliance purposes or when compliance forms are generated by the program.

The basis of the Standard Design is prescriptive Package A, which is contained in §150.1(c) of the Standards, Table 150.1-A. The Package A requirements (not repeated here) vary by climate zone. Reference Joint Appendix JA2, Table 2-1 contains the 16 California climate zones and their representative city. The climate zone can be found by city, county and zip code in JA2.1.1. The following sections present the details on how the Proposed Design and Standard Design are determined.

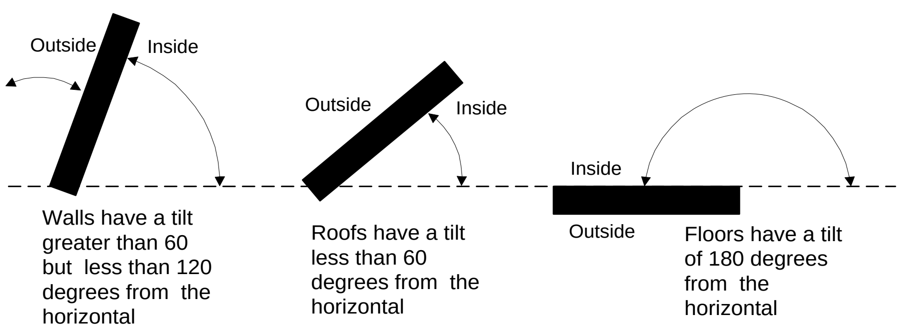
For many modeling assumptions, the Standard Design is the same as the Proposed Design. Only when a building has Special Features, for which the Commission has established alternate modeling assumptions, will the Standard Design use features that differ from the Proposed Design so the building receives appropriate credit for its efficiency. Typically, these measures require verification. Alternate features, such as zonal control, are documented as Special Features on the Certificate of Compliance. Verified features are documented on the CF-1R.

2.2 The Building

The building configuration is defined through entries for floor areas, building volume, wall areas, roof and ceiling areas, fenestration areas, and door areas (all surfaces separating conditioned space from exterior or unconditioned spaces such as a garage or storage). Each are entered along with performance characteristics such as U-factors, SHGC, construction, etc. The orientation and tilt (see Figure 2-1) is required for walls, fenestration and other elements. Building elements shall be consistent with the actual building design and configuration.

Wall and window areas are distributed equally between the four main compass points, North, East, South and West to determine the Standard Design. For alterations and additions, the Standard Design shall have the same wall and fenestration areas and orientations as the proposed building. The details are described below.

Figure 2-1: Surface Definitions



2.2.1 Standards Version

This input determines which federal appliance efficiency requirements for cooling equipment apply to this project. They allow the user to choose compliance that will be valid only before the federal requirements change or compliance that will be valid both before and after the change. Eligibility for solar electric system credit also depends on this choice.

PROPOSED DESIGN

The user inputs his choice of:

Compliance 2014: valid through December 2014 (with current Federal Air Conditioning efficiency requirements

Compliance 2015: any time (with 2015 Federal Air Conditioning Requirements) and solar credit.

STANDARD DESIGN

The standard design cooling equipment efficiency is based on the specified version of the federal requirements. If Compliance 2015 is selected, a minimum EER meeting the 2015 standard is included.

VERIFICATION & REPORTING

Compliance version is reported on the CF1R

2.2.2 Climate and Weather

PROPOSED DESIGN

The user inputs the zip code of the address of the proposed building and the software automatically selects the Climate Zone for compliance requirements and calculation inputs. The weather file, design temperatures and Time Dependent Valuation (TDV) of energy factors are a function of the Climate Zone. Compliance software assumes that the ground surrounding residential buildings has a reflectivity of 20 percent in both summer and winter.

STANDARD DESIGN

The standard design Climate Zone is the same as the Proposed Design.

VERIFICATION & REPORTING

The zip code and climate zone of the proposed design is reported on the CF1 for verification.

2.2.3 Air Leakage and Infiltration

Air leakage is a building level characteristic. The Compliance Software distributes the leakage over the envelope surfaces in accordance with the building configuration and constructs a pressure flow network to simulate the air flows between the conditioned zones, unconditioned zones and outside.

2.2.3.1 CFM50 and ACH50

The air flow through a blower door at 50 pascals (Pa) of pressure measured in cubic feet per minute is called CFM50. CFM50 x 60 minutes divided by the volume of conditioned space is the air changes per hour at 50 Pa, called ACH50. Either CFM50 or ACH50 can be used to describe the leakage of the building depending on the circumstances.

PROPOSED DESIGN

ACH50 defaults to 5 for new construction in single family buildings and 7 for all other buildings that have heating and/or cooling system ducts outside of conditioned space. In buildings with no heating and/or cooling system ducts in unconditioned space the default ACH50 is 4.4 for single family detached and 6.2 for all others.

Specific data on ACH50 may be entered if the single family house or townhouse will have verified building air leakage testing. In multi-family buildings, due to the lack of an applicable measurement standard, ACH50 is fixed at the above defaults and is not a compliance variable. User input of an ACH50 less than the default value is a Special Feature that requires post-construction verification.

STANDARD DESIGN

The Standard Design shall have 5 ACH50.

VERIFICATION AND REPORTING

Diagnostic Testing for Reduced Infiltration. When the user chooses verified building air leakage testing, the diagnostic testing shall be performed using procedures specified in Reference Residential Appendix RA3.8. The specifications for diagnostic testing and the target values specified above shall be reported in the HERS Required Verification listings on the Certificate of Compliance.

2.2.3.2 Defining Air Net Leakage

The Compliance Software shall create an air leakage network for the Proposed and Standard Design using the user input building description. Air leakage is distributed across the envelope surfaces according to the factors in Table 2-1. The air network shall be insensitive to wind direction. For buildings modeled with multiple conditioned zones, a 20 square foot open door shall be assumed between any two conditioned zones where a door is shown on the plans. A 30 square foot open stairwell shall be assumed between any two conditioned zones where a stair is shown on the plans.

The only difference between the air network for the Proposed and Standard Designs is the ACH50 if the user specifies a value lower than the default.

Table 2-1: Air Leakage Distribution

	% of Total Leakage by Surface			
Configuration	Ceilings	Floors	Exterior Walls	House to Garage Surfaces
Slab on grade	50	0		
Raised Floor	40	10		
No Garage			50	0
Attached Garage			40	10

2.2.4 High Quality Insulation Installation

The Compliance Software user may specify either Unverified or Verified high quality insulation installation for the Proposed Design. Buildings with Unverified insulation installation are modeled with lower performing cavity insulation in framed walls, ceilings and floors and with added winter heat flow between the conditioned zone and attic to represent construction cavities open to the attic (see Table 2-2). Unverified insulation does not affect the performance of continuous sheathing in any construction.

PROPOSED DESIGN

The Compliance Software user may specify Verified high quality insulation installation at the building level.

The default is Unverified insulation installation.

STANDARD DESIGN

The Standard Design shall be modeled with Unverified insulation installation quality.

VERIFICATION AND REPORTING

The presence of Verified high quality insulation installation shall be reported in the HERS Required Verification listings on the CF-1R. Verified high quality insulation installation shall be certified by the installer and field verified to comply with RA3.5. Credit for Verified high quality insulation installation is applicable to ceilings/attics, knee walls, exterior walls and exterior floors.

Table 2-2: Modeling Rules for Unverified Insulation Installation Quality

Component	Modification
Walls	Multiply the cavity insulation R-value/inch by 0.7
Ceilings/Roofs	Multiply the blown and batt insulation R-value/inch by 0.96-0.00347*R
Ceiling below attic	Add a heat flow from the conditioned zone to the attic of 0.015 times the area of the ceiling below attic times (the conditioned zone temperature - attic temperature) whenever the attic is colder than the conditioned space

For alterations to existing pre-1978 construction, no wall degradation shall be assumed for the existing wall since this construction is assumed to have no insulation to degrade.

2.2.5 Dwelling Unit Types

Internal gains and indoor air quality (IAQ) ventilation calculations depend on the Conditioned Floor Area and number of bedrooms. For single-family homes this is straightforward, but for multifamily buildings with individual IAQ ventilation systems each different combination of bedrooms and conditioned floor area has a different minimum ventilation CFM that must be verified. A dwelling unit type is one or more dwelling units in the building, each of which has the same floor area, number of bedrooms and appliances.

PROPOSED DESIGN

For each dwelling unit type the user inputs the following information:

- Unit name
- Number of this unit in building

- Conditioned Floor Area (CFA) in square feet
- Number of bedrooms
- Unit has dishwasher?
- Unit has clothes washer and dryer or hookups provided?

STANDARD DESIGN

The Standard Design shall have the same number and type of dwelling units as the Proposed Design.

VERIFICATION AND REPORTING

The number of units of each type and minimum IAQ ventilation for each unit shall be reported on the CF1 for use in field verification.

2.2.6 Orientation

The input for the building front orientation is the azimuth of the front of the building. This will generally be the side of the building where the front door is located. The orientation of the other sides of a rectangular building viewed from the outside looking at the front door are called left, right and back and the Compliance Software calculates their azimuth from this input.

PROPOSED DESIGN

The user chooses whether he wants compliance for any orientation or for the building oriented at a specific orientation. For the specific orientation case, input the azimuth of the front.

STANDARD DESIGN

The Compliance Software constructs a Standard Design building that has 25% of the wall and window area facing each cardinal orientation.

VERIFICATION AND REPORTING

A typical reported value would be "290° (west)". This would indicate that the front of the building faces north 70° west in surveyors terms. The closest orientation on 45° compass points should be verbally reported in parenthesis, e.g., north, northeast, east, southeast, south, southwest, west or northwest. When compliance is shown for multiple orientations, "all orientations" may be reported. When "all orientations" is reported it shall be included in the Special Features Inspection Checklist.

2.2.7 Natural Gas Availability

PROPOSED DESIGN

The user specifies whether natural gas is available at the site.

STANDARD DESIGN

The Standard Design has natural gas water heating if natural gas is available at the site; otherwise it is liquefied petroleum gas (LPG).

VERIFICATION AND REPORTING

2.2.8 Solar

For users with single family and town house projects in Climate Zone 9 through 15 who select Compliance 2015 to comply under the updated federal appliance standards, there is a credit available for photovoltaic systems. The photovoltaic systems must be 2 kWDC or larger. The credit is the smaller of:

PV Generation Rate (kTDV/kWdc) * kWdc

Max PV Cooling Credit * Standard Design Cooling Energy (kTDV)

Where the factors are shown in Table 2-3.

Table 2-3: PV Credit Calculation Factors

Climate Zone	PV Generation Rate (kTDV/kWdc)	Max PV Cooling Credit (% of Standard Design Cooling kTDV/ft2)
09	30269	13%
10	30342	15%
11	29791	18%
12	29556	17%
13	29676	17%
14	31969	16%
15	29536	19%

PROPOSED DESIGN

For users in the applicable climate zone with the applicable project type and standards version the software allows the the user to input the rated power of the solar system in kilowatts DC. The software automatically calculates the solar credit.

STANDARD DESIGN

The standard design has no PV system

VERIFICATION AND REPORTING

A solar credit is a special feature that is reported on the CF1R.

2.2.9 Materials and Construction Assemblies

The Compliance Software allows the user to create and edit construction assemblies.

2.2.9.1 Materials

Only materials approved by the commission may be used in defining constructions. Table 2-3 shows the materials available for construction assemblies.

Table 2-4: Materials List

Material Name	Thickness (in.)	Conductivity (Btu/h-°F-ft)	Coefficient for Temperature Adjustment of Conductivity (°F(-1))	Specific Heat (Btu/lb-°F)	Density (lb/ft3)	R-Value per Inch (°F-ft2-h/Btu-in)
Gypsum Board	0.5	0.09167		0.27	40	0.9091
Wood layer	0.5	0.06127		0.45	41	1.36
R4 Synth Stucco	1	0.02083	0.00418	0.35	1.5	4
3 Coat Stucco	0.875	0.4167		0.2	116	0.2
Carpet	0.5	0.02		0.34	12.3	4.1667
Light Roof	0.2	1		0.2	120	0.0833
5 PSF Roof	0.5	1		0.2	120	0.0833
10 PSF Roof	1	1		0.2	120	0.0833
15 PSF Roof	1.5	1		0.2	120	0.0833
25 PSF Roof	2.5	1		0.2	120	0.0833
TileGap	0.75	0.07353		0.24	0.075	1.1333
SlabOnGrade	3.5	1		0.2	144	0.0833
Earth		1		0.2	115	0.0833
Crawl	12	0.16667		0.24	0.075	0.5
SoftWood		0.08167		0.39	35	1.0204
Concrete		1		0.2	144	0.0833
R1 Sheathing	1	0.08333	0.00418	0.35	1.5	1
R2 Sheathing	1	0.04167	0.00418	0.35	1.5	2
R3 Sheathing	1	0.02778	0.00418	0.35	1.5	3
R4 Sheathing	1	0.02083	0.00418	0.35	1.5	4
R5 Sheathing	1	0.01667	0.00418	0.35	1.5	5
R6 Sheathing	1	0.01389	0.00418	0.35	1.5	6
R7 Sheathing	1	0.0119	0.00418	0.35	1.5	7
R8 Sheathing	1	0.01042	0.00418	0.35	1.5	8

MATERIAL NAME

The material name is used to select the material for a construction.

THICKNESS

Some materials such as 3 coat stucco are defined with a specific thickness (not editable by the compliance user) that is listed in the table. The thickness of other materials, such as Softwood used for framing, is specified by the compliance user based on the constructions in the building.

CONDUCTIVITY

The conductivity of the material is the steady state heat flow per square foot, per foot of thickness, per degree Fahrenheit temperature difference. It is used in simulating the heat flow in the construction.

COEFFICIENT FOR TEMPERATURE ADJUSTMENT OF CONDUCTIVITY

The conductivity of insulation materials varies hourly with their temperature according to the coefficient listed. Other materials have a coefficient of 0 and their conductivity does not vary with temperature.

SPECIFIC HEAT

The specific heat is the amount of heat in Btu it takes to raise the temperature of one pound of the material one degree Fahrenheit.

DENSITY

The density of the material is its weight in pounds per cubic foot.

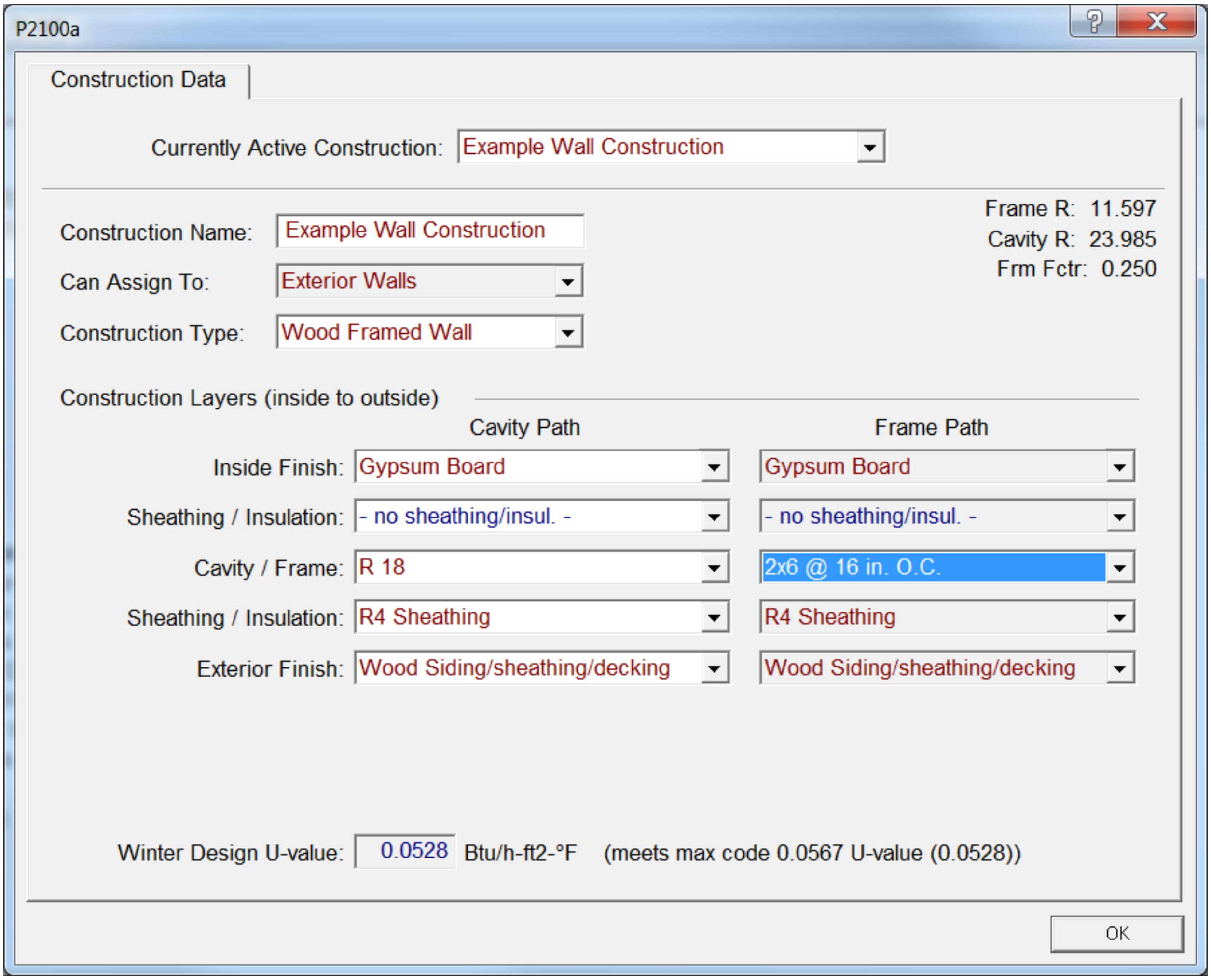
R-VALUE PER INCH

The R-value is the resistance to heat flow for a 1 inch thick layer.

2.2.9.1 Constructions

Constructions are defined by the compliance user for use in exterior walls, interior walls, attic roofs, cathedral ceilings, ceilings (below attic), exterior floors, and interior floors. The user assembles a construction from one or more layers of materials as shown in Figure 2-2. For framed constructions there is a framing layer that has parallel paths for the framing and the cavity between the framing members. The layers that are allowed depend on the surface type. The Compliance Manager calculates a winter design U-factor and compares it to the U-factor of a construction that meets the prescriptive Standards. The U-factor is displayed as an aid to the user and is not used in the energy simulation.

Figure 2-2: Example Construction Data Screen



PROPOSED DESIGN

The user defines a construction for each surface type included in the Proposed Design. Any variation in insulation R-value, framing size or spacing, interior or exterior sheathing or interior or exterior finish requires the user to define a different construction. Insulation R-values shall be based on manufacturers rated properties rounded to the nearest whole R. Layers such as sheetrock, wood sheathing, stucco and carpet whose properties are not compliance variables are included as generic layers with standard thickness and properties.

STANDARD DESIGN

The Compliance Software assembles a construction meeting the prescriptive Standards for each user-defined construction.

VERIFICATION AND REPORTING

All proposed constructions shall be documented in the compliance reports.

2.2.10 Heating Subsystems

The heating subsystem describes the equipment that supplies heat to an HVAC System. Heating systems are categorized according to the types show in Table 2-4.

Table 2-5: HVAC Heating Equipment Descriptors

Recommended Descriptor	Heating Equipment Reference
CntrlFurnace	Gas- or oil-fired central furnaces, propane furnaces or heating equipment considered equivalent to a gas-fired central furnace, such as wood stoves that qualify for the wood heat exceptional method. Gas fan-type central furnaces have a minimum AFUE=78%. Distribution can be gravity flow or use any of the ducted systems. [Efficiency Metric: AFUE]
Heater	Non-central gas- or oil-fired space heaters, such as wall heaters floor heaters or unit heater. Equipment has varying efficiency requirements. Distribution is ductless and may be gravity flow or fan-forced. Can refer to floor furnaces and wall heaters within the description field for CntrlFurnaces, [Efficiency Metric: AFUE]
Boiler	Gas or oil boilers. Distribution systems can be Radiant, Baseboard or any of the ducted systems. Boiler may be specified for dedicated hydronic systems. Systems in which the boiler provides space heating and fires an indirect gas water heater (IndGas) may be listed as Boiler/CombHydro Boiler and shall be listed under "Equipment Type" in the HVAC Systems listing. [Efficiency Metric: AFUE]
SplitHeatPump	Heating side of central split system heat pump heating systems. Distribution system shall be one of the ducted systems. [Efficiency Metric: HSPF]
PkgHeatPump	Heating side of central packaged heat pump systems. Central packaged heat pumps are heat pumps in which the blower, coils and compressor are contained in a single package, powered by single phase electric current, air cooled, rated below 65,000 Btuh. Distribution system shall be one of the ducted systems. [Efficiency Metric: HSPF]
LrgPkgHeatPump	Heating side of large packaged units rated at or above 65,000 Btu/hr (heating mode). Distribution system shall be one of the ducted systems. These include water source and ground source heat pumps. [Efficiency Metric: COP]
RoomHeatPump	Heating side of non-central room air conditioning systems. These include small ductless split system heat pump units and packaged terminal (commonly called "through-the-wall") units. Distribution system shall be Ductnone. [Efficiency Metric: COP]
Electric	All electric heating systems other than space conditioning heat pumps. Included are electric resistance heaters, electric boilers and storage water heat pumps (air-water) (StoHP). Distribution system can be Radiant, Baseboard or any of the ducted systems. [Efficiency Metric: HSPF]
CombHydro	Water heating system can be storage gas (StoGas, LgStoGas), storage electric (StoElec) or heat pump water heaters (StoHP). Distribution systems can be Radiant, Baseboard, or any of the ducted systems and can be used with any of the terminal units (FanCoil, RadiantFlr, Baseboard, and FanConv).

Proposed Design

The user selects the type and supplies inputs for the heating subsystem in the Heating System Data screen shown in Figure 2-3 and Figure 2-4. The user inputs the appropriate rated heating efficiency factor. The rated heating capacity not a compliance variable and is calculated for use in the simulation by the Compliance Software for all systems except heat pumps. For heat pumps the user inputs the rated heating capacity at 17F and 47F of the heat pump compressor that will be installed and the software sizes the backup electric resistance heat for use in the simulation.

If the system is a non-ducted non-central gas furnace system, the Compliance Software shall require the user to select the type and size of the equipment from the Appliance Efficiency Regulations for Gas Fired Wall Furnaces, Floor Furnaces and Room Heaters, where the system size, as a default, may be determined as 34 Btu/hour per square foot of conditioned floor area to establish the Standard Design efficiency.

STANDARD DESIGN

When electricity is used for heating, the heating equipment for the Standard Design shall be an electric split system heat pump with a Heating Seasonal Performance Factor (HSPF) meeting the Appliance Efficiency Regulations requirements for split systems, unless the Proposed Design is a non-ducted room heat pump, in which case the Standard Design is the same. The Standard Design heat pump compressor size is determined by the software based on the compressor size calculated for the air conditioning system.

When electricity is not used for heating, the equipment used in the Standard Design building shall be a gas furnace with an Annual Fuel Utilization Efficiency (AFUE) meeting the Appliance Efficiency Regulations minimum efficiency for central systems, unless the Proposed Design is a non-ducted system, in which case the Standard Design is the same. When a Proposed Design uses both electric and non-electric heat, the Standard Design shall be a gas furnace.

Figure 2-3: Heating System Data Screen

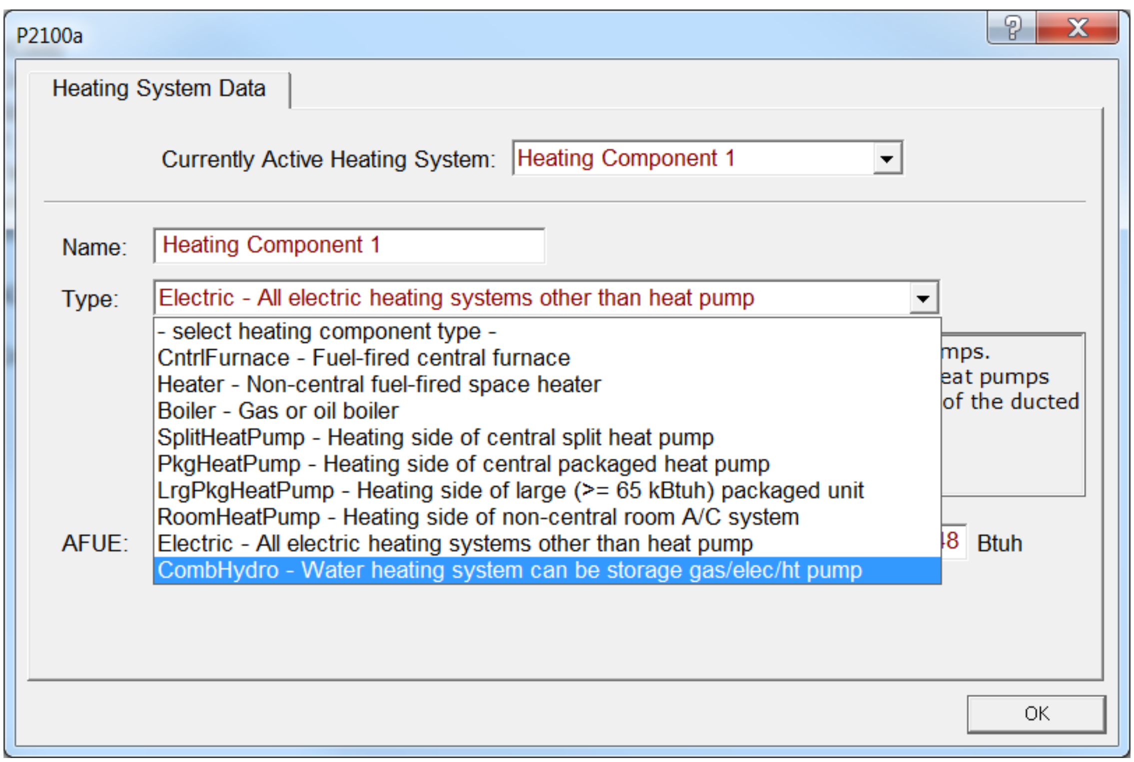
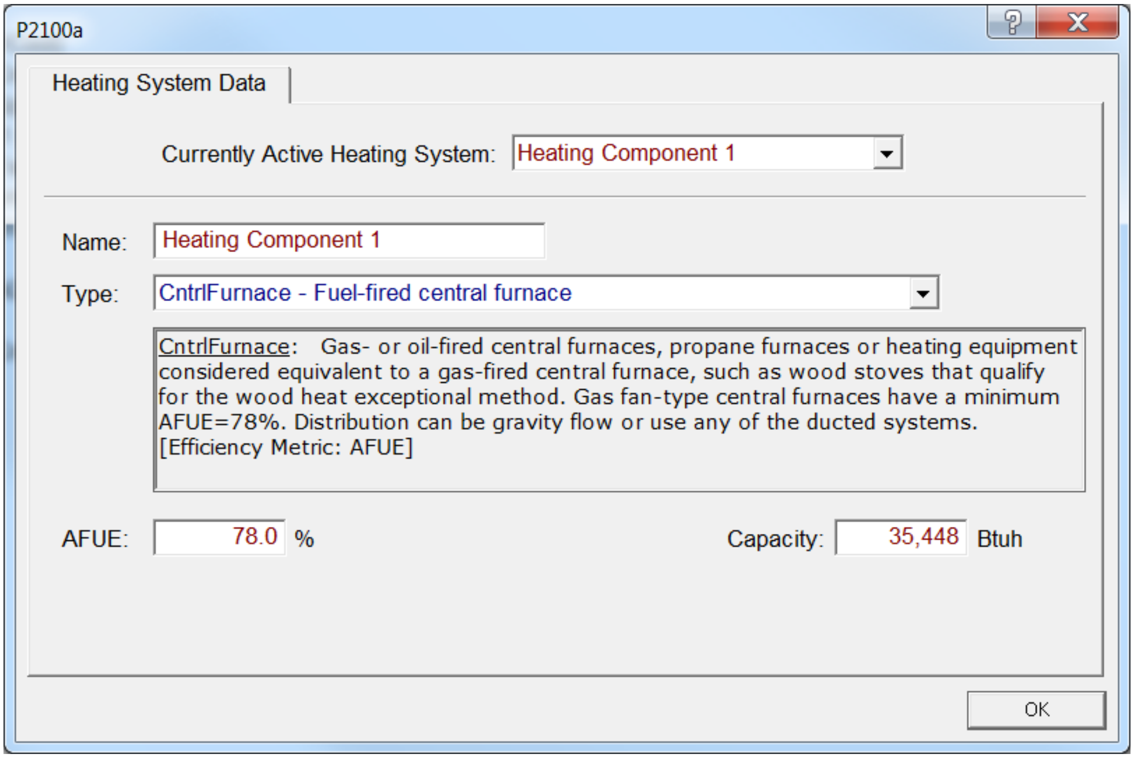


Figure 2-4: Heating System Data Screen



VERIFICATION AND REPORTING

The proposed heating system type and rated efficiency shall be reported in the compliance reports. The rated heating capacity of each proposed heat pump is reported on the CF1 so that installed size can be verified to be at least as large.

Special Systems – Hydronic Distribution Systems and Terminals

This listing shall be completed for hydronic systems that have more than 10 feet of piping (plan view) located in unconditioned space. As many rows as necessary may be used to describe the piping system. Note that hydronic heating systems (combined or not) shall be reported in the *Special Features Inspection Checklist*. The entry for the *Special Features Inspection Checklist* shall indicate any additional listings that are reported for this feature so that the local enforcement agency can verify the additional information needed to check this special feature.

Information to be provided on the CF-1R may include:

- *Piping Run Length (ft)*. The length (plan view) of distribution pipe located in unconditioned space, in feet, between the primary heating/cooling source and the point of distribution.
- *Nominal Pipe Size (in.)*. The nominal (as opposed to true) pipe diameter in inches.
- *Insulation Thickness (in.)*. The thickness of the insulation in inches. Enter "none" if the pipe is uninsulated.

- *Insulation R-value (hr-ft²- ℉/Btu).* The installed R-value of the pipe insulation. Minimum pipe insulation for hydronic systems is as specified in §150(j).

2.2.11 Cooling Subsystems

The cooling subsystem describes the equipment that supplies cooling to an HVAC System.

Table 2-6: HVAC Cooling Equipment Descriptors

Recommended Descriptor	Cooling Equipment Reference
NoCooling	Entered when the proposed building is not air conditioned or when cooling is optional (to be installed at some future date). Both the Standard Design equivalent building and the Proposed Design use the same default system (refer to sections 3.9.4. [Efficiency Metric: SEER]
SplitAirCond	Split air conditioning systems. Distribution system shall be one of the ducted systems. [Efficiency Metric: SEER and EER]
PkgAirCond	Central packaged air conditioning systems less than 65,000 Btuh cooling capacity. Distribution system shall be one of the ducted systems. [Efficiency Metric: SEER and EER]
LrgPkgAirCond	Large packaged air conditioning systems rated at or above 65,000 Btu/hr (cooling capacity). Distribution system shall be one of the ducted systems. [Efficiency Metric: EER]
RoomAirCond	Non-central room air conditioning cooling systems. These include small ductless split-system air conditioning units and packaged terminal (commonly called through-the-wall) air conditioning units. Distribution system shall be Ductnone. [Efficiency Metric: EER]
SplitHeatPump	Cooling side of split heat pump systems. Distribution system shall be one of the ducted systems. [Efficiency Metric: SEER and EER<65,000 Btu/hr EER>65,000 Btu/hr]
PkgHeatPump	Cooling side of central single-packaged heat pump systems with a cooling capacity less than 65,000 Btuh. Distribution system shall be one of the ducted systems. [Efficiency Metric: SEER]
LrgPkgHeatPump	Cooling side of large packaged heat pump systems rated at or above 65,000 Btu/hr (cooling capacity). Distribution system shall be one of the ducted systems. [Efficiency Metric: EER]
GasCooling	Gas absorption cooling. Three descriptors, COP95, the rated COP for the gas portion, CAP95, the rated capacity, and PPC, the parasitic electric energy at rated conditions in Watts.
RoomHeatPump	Cooling side of non-central, room heat pump systems. These include small ductless split-system air conditioning units and packaged terminal (commonly called “through-the-wall”) units. Distribution system shall be Ductnone. [Efficiency Metric: EER]
EvapDirect	Direct evaporative cooling systems. Assume minimal efficiency air conditioner. The default distribution system location is DuctAttic; evaporative cooler duct insulation requirements are the same as those for air conditioner ducts. [Efficiency Metric: SEER]
EvapIndirDirect	Indirect-direct evaporative cooling systems. Assume energy efficiency ratio of 13 EER.
EvapIndirect	Indirect evaporative cooling systems. Assume energy efficiency ratio (EER) or 13. The default distribution system location is DuctAttic; evaporative cooler duct insulation requirements are the same as those for air conditioner ducts. [Efficiency Metric: EER]
Evap/CC	Evaporatively Cooled Condensers. A split mechanical system, with a water-cooled condenser coil. (Efficiency metric: EER)
IceSAC	Ice Storage Air Conditioning. Split air conditioner condensing coil in combination with ice storage. (Efficiency metric in system performance tables)

Table 2-7: Cooling Zoning Descriptors

Zoning Type	Description
ZonalSingleSpeed	A ducted cooling system with a single speed compressor and zone control dampers
ZonalMultiSpeed	A ducted cooling system with a multiple speed or variable speed compressor and zone control dampers
NotZonal	Any cooling system that has no zone control dampers

PROPOSED DESIGN

The user selects the type of cooling equipment from Table 2-5 and enters basic information to model the energy use of the equipment. At a minimum, enter the Cooling Equipment Descriptor, zoning type, SEER, and whether the system is ducted or non-ducted. For ducted cooling systems the cooling air flow from the conditioned zone through the cooling coil is an input. If the cooling system is non-ducted, the software shall require the user to select the type and capacity of the equipment from the Appliance Efficiency Regulations for Room Air Conditioners, Room Air Conditioning Heat Pumps, Package Terminal Air Conditioners and Package Terminal Heat Pumps. The rated cooling capacity not a compliance variable and is calculated for use in the simulation by the Compliance Software for all systems. See sections below for the details of specific inputs.

STANDARD DESIGN

The cooling system for the Standard Design building shall be a NotZonal split system air conditioner or heat pump meeting the minimum Package A prescriptive requirements. The Standard Design system shall assume verified refrigerant charge in climate zones 2 and 8 to 15 and mandatory fan efficacy in all climate zones.

VERIFICATION AND REPORTING

Table 2-8: Summary of Air Conditioning Measures Requiring Verification

Measure	Description	Procedures (Need Update)
Verified Refrigerant Charge	Air-cooled air conditioners and air-source heat pumps be diagnostically tested to verify that the system has the correct refrigerant charge. The system must also meet the System Airflow requirement.	RA3.2, RA1.2
Verified Charge Indicator Display	A Charge Indicator Display can be installed as an alternative to refrigerant charge testing.	RA3.4.2
Verified System Airflow	When compliance requires verified System Airflow greater than or equal to a specified criterion.	RA3.3
Verified Air-handling Unit Fan Efficacy	To verify that Fan Efficacy (Watt/cfm) is less than or equal to a specified criterion,	RA3.3
Verified EER	Credit for increased EER by installation of specific air conditioner or heat pump models	RA3.4.3, RA3.4.4.1
Verified SEER	Credit for increased SEER	RA3.4.3, RA3.4.4.1
Evaporatively Cooled Condensers	Must be combined with Refrigerant Charge, and Verified EER.	RA3.1.4.3, RA3.2, RA3.4.3, RA3.4.4.1
Ice Storage Air Conditioners		RA3.1.4.3, RA3.2, RA3.4.3, RA3.4.4.1

Verified Refrigerant Charge or Charge Indicator Display

Proper refrigerant charge is necessary for electrically driven compressor air conditioning systems to operate at full capacity and efficiency. Software calculations set the a compresser efficiency multiplier to 0.90 to account for the impact of improper refrigerant charge or 0.96 for proper charge.

PROPOSED DESIGN

The software shall allow the user to indicate if systems have diagnostically tested refrigerant charge or a field verified charge indicator display. This applies only to ducted split system and package air conditioners and heat pumps, as well as mini-split heat pumps.

STANDARD DESIGN

The Standard Design building shall be modeled with either diagnostically tested refrigerant charge or a field verified charge indicator display if required for the proposed cooling system type.

VERIFICATION AND REPORTING

These features require field verification or diagnostic testing and shall be reported in the *HERS Required Verification* listings on the CF-1R. Details on refrigerant charge measurement are discussed in Reference Residential Appendix RA. Information on the requirements for charge indicator displays is located in Reference Joint Appendix JA6.1.

System Return Air Flow

Adequate return air flow from the conditioned space is required to allow ducted air conditioning systems to operate at their full efficiency and capacity. Efficiency is achieved by the air distribution system design, by improving the efficiency of motors or air distribution systems with less resistance to air flow. Software calculations account for the impact of air flow on sensible heat ratio and compressor efficiency.

PROPOSED DESIGN

The default cooling air flow is 260 CFM/ton for ZonalSingleSpeed systems and 350 CFM/ton for all other ducted cooling systems. However, users may specify a higher air flow and receive credit in the compliance calculation if greater verified system air flow is specified and diagnostically tested using the procedures of Reference Residential Appendix RA3.

STANDARD DESIGN

The Standard Design shall assume a verified system airflow of 350 cfm per ton.

VERIFICATION AND REPORTING

System air flow shall be reported in the *HERS Required Verification* listings of the CF-1R. Air flow shall be tested, certified and verified using the procedures of Reference Residential Appendix RA3.3.

Verified Energy Efficiency Ratio (EER)

PROPOSED DESIGN

Software shall allow the user the option to enter an EER rating for cooling equipment. For equipment that is rated only with an EER (some evaporative coolers, room air conditioners), the user will enter the efficiency as an SEER.

STANDARD DESIGN

The Standard Design does not include an EER rating for cooling equipment.

VERIFICATION AND REPORTING

Verified EER shall be reported in the *HERS Required Verification* listings on the CF-1R. The EER rating will be verified using rating data from AHRI Directory of Certified Product Performance at www.ahridirectory.org or another directory of certified product performance ratings approved by the Commission for determining compliance.

Verified Seasonal Energy Efficiency Ratio (SEER)

PROPOSED DESIGN

The software allows the user to specify a SEER higher than the default minimum.

STANDARD DESIGN

The Standard Design is based on the default minimum efficiency SEER for the type of cooling equipment specified in the Proposed Design.

VERIFICATION AND REPORTING

If a SEER higher than the default minimum efficiency is specified in software, the SEER requires field verification. The higher than minimum SEER rating will be verified using rating data from AHRI Directory of Certified Product Performance at www.ahridirectory.org or another directory of certified product performance ratings approved by the Commission for determining compliance. Verified SEER shall be reported in the *HERS Required Verification* listings on the CF-1R.

Verified Evaporatively-Cooled Condensers

PROPOSED DESIGN

Software shall allow users to specify an evaporatively cooled condensing unit. The installation must comply with the requirements of RA4.3.2 to ensure the predicted energy savings are achieved. This credit must be combined with verified refrigerant charge testing. Verified evaporatively-cooled condensing unit and its required measures shall be reported in the *HERS Required Verification* listings on the CF-1R.

STANDARD DESIGN

The Standard Design is based on a split system air conditioner meeting the requirements of Package A.

VERIFICATION AND REPORTING

Verified Ice Storage Air Conditioners

PROPOSED DESIGN

Software shall allow users to specify Ice Storage Air Conditioners (ISAC). The installation must comply with the requirements of RA4.3.1 to ensure the predicted energy savings are achieved. This credit must be combined with verified duct sealing and verified refrigerant charge testing. Verified ISAC and its required measures shall be reported in the *HERS Required Verification* listings on the CF-1R.

STANDARD DESIGN

The Standard Design is based on a split system air conditioner meeting the requirements of Package A.

VERIFICATION AND REPORTING

Evaporative Cooling

PROPOSED DESIGN

Software shall allow users to specify an evaporative cooler.

STANDARD DESIGN

The Standard Design is based on a split system air conditioner meeting the requirements of Package A.

VERIFICATION AND REPORTING

The installation must comply with the requirements of RA4.3.2 to ensure the predicted energy savings are achieved its required measures shall be reported in the *HERS Required Verification* listings on the CF-1R.

2.2.12 Fan Systems

Fan systems move air for air conditioning, heating and ventilation systems. The software allows the user to define fan systems to be used in HVAC, cooling ventilation and indoor air quality ventilation systems.

PROPOSED DESIGN

For each fan system, the user selects the type of equipment from Table 2-7 and enters basic information to model the energy use of the equipment. For ducted central air conditioning and heating systems the fan efficacy default is the mandatory minimum verified efficacy of 0.58 W/CFM.

STANDARD DESIGN

The Standard Design fan shall meet the minimum Package A prescriptive requirements.

VERIFICATION AND REPORTING

Non default fan efficacy shall be reported in the *HERS Required Verification* listings on the CF-1R. Minimum verified fan efficacy is a mandatory requirement for all ducted cooling systems.

Table 2-9: Fan System Types

Measure	Description	Inputs
Single Speed PSC Furnace Fan	Typical furnace fan used in central heating and air conditioning systems. Mandatory verified minimum efficacy of 0.58 W/CFM.	CFM, W/CFM
BPM Furnace Fan	Brushless Permanent Magnet type furnace fan used in central heating and air conditioning systems. Mandatory verified minimum efficacy of 0.58 W/CFM at full system air flow.	CFM, W/CFM
Whole House Fan	Traditional whole house fan cooling ventilation system. Efficacy in W/CFM as listed in the CEC directory.	CFM, W/CFM
Standalone IAQ fan	Dedicated single speed indoor air quality ventilation fan system. Type is Supply, Exhaust or Balanced as defined in ASHRAE Standard 62.2. If type is balanced can have heat recovery.	CFM, W/CFM, Type, Heat Recovery Effectiveness.
Variable Speed Integrated ventilation Cooling	Variable speed HVAC and cooling ventilation system	

Fixed Speed Integrated ventilation Cooling	Single speed HVAC and cooling ventilation system	
Central Fan Integrated IAQ system	IAQ system that uses the typical furnace fan in central heating and air conditioning system to provide IAQ ventilation	

2.2.13 Distribution Subsystems

If multiple HVAC distribution systems serve a building each system and the conditioned space it serves may be modeled in detail separately or the systems may be aggregated together and modeled as one large system. If the systems are aggregated together they must be the same type and all meet the same minimum specifications.

For the purposes of duct efficiency calculations, the supply duct begins at the exit from the furnace or air handler cabinet.

> Credit is available for supply duct systems entirely in conditioned space, with reduced surface area in unconditioned spaces and varying combinations of higher performance insulation. In order to claim these credits the detailed duct system design shall be documented on the plans, and the installation shall be certified by the installer and verified by a HERS rater. The size, R-value, and location of each duct segment in an unconditioned space and if buried in attic insulation, the information described below shall be shown in the design and entered into the Compliance Software. The Compliance Software shall calculate the area and effective R-value of the duct system in each location using the procedures specified below.

Table 2-10: HVAC Distribution Type and Location Descriptors

Recommended Descriptors	HVAC Distribution Type and Location Reference
Air Distribution Systems	Fan-powered, ducted distribution systems that can be used with most heating or cooling systems. When ducted systems are used with furnaces, boilers, or combined hydronic/water heating systems the electricity used by the fan shall be calculated. R-value shall be specified in "Duct R-value" column when a ducted system is specified
DuctsAttic	Ducts located overhead in the unconditioned attic space
DuctsCrawl	Ducts located underfloor in the unconditioned crawlspace
DuctsCVC	Ducts located underfloor in a controlled ventilation crawlspace space
DuctsGarage	Ducts located in an unconditioned garage space.
DuctsBasemt	Ducts located in an unconditioned basement space
DuctsInEx12	Ducts located within the conditioned floor space except for less than 12 lineal feet of duct, typically an HVAC unit in the garage mounted on return box with all other ducts in conditioned space.
DuctsInAll	HVAC unit or systems with all HVAC ducts located within the conditioned floor space. Location of ducts in conditioned space eliminates conduction losses but does not change losses due to leakage. Leakage from either ducts that are not tested for leakage or from sealed ducts is modeled as leakage

Recommended Descriptors	HVAC Distribution Type and Location Reference
	to outside the conditioned space.
DuctsNone	Air distribution systems without ducts such as ductless split system air conditioners and heat pumps, window air conditioners, through-the-wall heat pumps, etc.
DuctsOutdoor	Ducts located in exposed locations outdoors.
Ductless Systems	Ductless radiant or warm/cold air systems using fan-forced or natural air convection such as ductless mini-split heat pumps and hydronic systems relying upon circulation pumps and fan-forced or natural air convection
Furnaces	Heating equipment such as wall and floor furnaces
Radiant	Radiant electric panels or fanless systems used with a boiler, electric or heat pump water heater, or combined hydronic heating equipment.
LowLlCod	Verified Low Leakage Ducts in Conditioned Space - defined as duct systems for which air leakage to outside conditions is equal to or less than 25 cfm when measured in accordance with Reference Residential Appendix RA3.1.4.3.9,
LowLkAH	Low Leakage Air Handlers – for factory sealed air handler unit tested by the manufacturer and certified to the Commission to have achieved a 2 percent or less leakage rate at 1-inch water gage – as prescribed in Reference Residential Appendix RA3.1.4.3.10.
Baseboard	Electric baseboards or hydronic baseboard finned-tube natural convection systems

PROPOSED DESIGN

The Compliance Software shall allow the user to select from the basic types of HVAC distribution systems and locations listed in Table 2-8. As a default, for ducted systems, HVAC ducts and the air handler are located in the attic.

Proposed HVAC systems with a duct layout and design on the plans may locate the ducts in the crawlspace or a basement if the layout and design specify that all of the supply registers are located in the floor or within two feet of the floor, and show the appropriate locations for the ducts. Otherwise, the default location is the attic.

Proposed HVAC systems with a complete duct design, including the duct layout and design on the plans, may allocate duct surface area in more detail in the Compliance Software model but the distribution of duct surface areas by location shall appear on the HERS Required Verification list of the CF-1R. The rater shall verify the existence of duct design and layout and the general consistency of the actual HVAC distribution system with the design.

The software shall allow users to specify any of the verified or diagnostically tested HVAC distribution systems or conditions in the Proposed Design (see Table 2-9). The default shall be that duct testing or verification of ducts in conditioned space is required for ducted systems.

Table 2-11: Summary of Verified Air Distribution Systems

Measure	Description	Procedures
Verified Duct Sealing	Mandatory measures require that space conditioning ducts be sealed. Field verification and diagnostic testing is required to verify that approved duct system materials are utilized and	RA3.1.4.3

Measure	Description	Procedures
	that duct leakage meets the specified criteria.	
Verified Supply Duct Location, Surface Area and R-value	Compliance credit can be taken for improved supply duct location, surface area and R-value. Field verification is required to verify that the duct system was installed according to the design, including location, size and length of ducts, duct insulation R-value and installation of buried ducts.[1] For buried ducts measures Verified High Quality Insulation Installation (QII) is required.	RA3.1.4.1
Verified Ducts in Directly Conditioned Space and Low Leakage Ducts in Conditioned Space	When the Standards specify use of the procedures in Section RA3.1.4.3.8 to determine if space conditioning system ducts are located entirely in directly conditioned space, the duct system location shall be verified by diagnostic testing. Compliance credit can be taken for verified duct systems with low air leakage to the outside when measured in accordance with Reference Residential Appendix Section RA3.1.4.3.8. Field Verification for ducts in conditioned space is required. Duct sealing is required.	RA3.1.4.3.8
Low Leakage Air-handling Units	Compliance credit can be taken for installation of a factory sealed air handling unit tested by the manufacturer and certified to the Commission to have met the requirements for a Low Leakage Air-Handling Unit achieved. Field verification of the air handler's model number is required. Duct Sealing is required.	RA3.1.4.3.9
Verified Return Duct Design	Verification to confirm that the return duct design conforms to the criteria given in Table 150.0-C or Table 150.0-D.	RA3.1.4.4

1. *Compliance credit for increased duct insulation R-value (not buried ducts) may be taken without field verification if the R-value is the same throughout the building, and for supply ducts located in crawlspaces and garages where all supply registers are either in the floor or within 2 feet of the floor. These two credits may be taken subject only to enforcement agency inspection.*

STANDARD DESIGN

The standard heating and cooling system for central systems is modeled with non-designed air distribution ducts located in an attic space attic or as described in Table 2-10, with verified tested duct leakage (see Table 2-13) and a radiant barrier in climate zones where required by Package A. The Standard Design duct insulation is determined by Package A as R-6 in climate zones 1-13, and R-8 in climate zones 14-16. The Standard Design building is assumed to have the same number of stories as the Proposed Design for purposes of determining the duct efficiency. For non-central HVAC systems, the Standard Design shall have no ducts.

Table 2-12: Summary of Standard Design Duct Location

Configuration of the Proposed Design	Standard Design	
	Standard Design Duct Location	**Detailed Specifications**
Attic over the dwelling unit	Ducts and air handler located in the attic	Ducts sealed (mandatory requirement) No credit for verified R-value, location or duct design
No attic but crawlspace or basement	Ducts and air handler located in the crawlspace or basement	
No attic, crawlspace or basement	Ducts and air handler located indoors	

This table is applicable only when the Standard Design system has air distribution ducts as determined in Table 2-8.

VERIFICATION AND REPORTING

VERIFICATION AND REPORTING

2.2.13.1 Duct Location

Duct location determines the external temperature for duct conduction losses, the temperature for return leaks, and the thermal regain of duct losses.

PROPOSED DESIGN

STANDARD DESIGN

VERIFICATION AND REPORTING

2.2.13.2 Return Duct Location

If return ducts are located entirely in the basement, the calculation shall assume basement conditions for the return duct efficiency calculation. If the return duct is located entirely in conditioned space and the system meets the requirements for *Verified Low Leakage Ducts in Conditioned* Space, the return duct shall be assumed to be in conditioned space. Otherwise, the return duct shall be entirely located in the attic for the purposes of conduction and leakage calculations. Return duct surface area is not a compliance variable.

PROPOSED DESIGN

STANDARD DESIGN

VERIFICATION AND REPORTING

2.2.13.3 Supply Duct Location

PROPOSED DESIGN

STANDARD DESIGN

VERIFICATION AND REPORTING

Default supply duct locations shall be as shown in Table 2-11. The supply duct surface area for crawlspace and basement applies only to buildings or zones with all supply ducts installed in the crawlspace or basement. If the supply duct is installed in locations other than crawlspace or basement, the default supply duct location shall be "Other." For houses with 2 or more stories 35 percent of the default duct area may be assumed to be in conditioned space as shown in Table 2-11.

The surface area of supply ducts located in conditioned space shall be ignored in calculating conduction losses.

Table 2-13: Location of Default Supply Duct Area

Supply duct location	Location of Default Supply Duct Surface Area	
	One story	Two or more story
All in Crawlspace	100% crawlspace	65% crawlspace 35% conditioned space
All in Basement	100% Basement	65% basement 35% conditioned space
Other	100% attic	65% attic 35% conditioned space

2.2.13.4 Verified Supply Duct Location

PROPOSED DESIGN

STANDARD DESIGN

VERIFICATION AND REPORTING

Supply duct location and areas other than the defaults shown in Table 2-11 may be used following the procedures in Reference Residential Appendix RA3.1.4.1.

2.2.13.5 Duct Surface Area

PROPOSED DESIGN

STANDARD DESIGN

VERIFICATION AND REPORTING

The supply-side and return-side duct surface areas shall be treated separately in distribution efficiency calculations. The duct surface area shall be determined using the following methods.

2.2.13.6 Return Duct Surface Area

PROPOSED DESIGN

STANDARD DESIGN

VERIFICATION AND REPORTING

Return duct surface area is not a compliance variable and shall be calculated using Equation 2-1.

Equation 2-1

$$A_{r,out} = K_r \times A_{floor}$$

Where K_r (return duct surface area coefficient) shall be 0.05 for one-story buildings and 0.1 for two or more stories.

2.2.13.7 Default Supply Duct Surface Area

PROPOSED DESIGN

STANDARD DESIGN

The Standard Design and [editor's note: should this say and Proposed Design?] default supply duct surface area shall be calculated using Equation 2-2.

Equation 2-2

$$A_{S,out} = 0.27 \times A_{floor} \times K_S$$

Where K_s (supply duct surface area coefficient) shall be 1 for one-story buildings and 0.65 for two or more stories.

VERIFICATION AND REPORTING

2.2.13.8 Supply Duct Surface Area for Less Than 12 feet of Duct Outside Conditioned Space

PROPOSED DESIGN

For Proposed Design HVAC systems with air handlers located outside the conditioned space but with less than 12 lineal feet of duct located outside the conditioned space including air handler and plenum, the supply duct surface area outside the conditioned space shall be calculated using Equation 2-3.

Equation 2-3

$$A_{s,out} = 0.027 \times A_{floor}$$

STANDARD DESIGN

VERIFICATION AND REPORTING

2.2.13.9 Diagnostic Duct Surface Area

PROPOSED DESIGN

Proposed Designs may claim credit for reduced surface area using the procedures in Reference Residential Appendix RA3.1.4.1.

The surface area of each supply duct system segment shall be calculated based on its inside dimensions and length. The total supply surface area in each unconditioned location (attic, attic with radiant barrier, crawlspace, basement, other) shall be the sum of the area of all duct segments in that location. The Compliance Software shall assign duct segments located in “other” locations to the attic location for purposes of calculation. The surface area of supply ducts completely inside conditioned space need not be input in the Compliance Software and is not included in the calculation of duct system efficiency. The area of ducts in floor cavities or vertical chases that are surrounded by conditioned space and separated from unconditioned space with draft stops are also not included.

2.2.13.10 Duct System Insulation

For the purposes of conduction calculations in both the Standard and Proposed Designs, 85 percent of the supply and return duct surface shall be assumed to be duct material at its specified R-value and 15 percent shall be assumed to be air handler, plenum, connectors and other components at the mandatory minimum R-value.

The area weighted effective R-value shall be calculated by the Compliance Software using Equation 2-4 and including each segment of the duct system that has a different R-value.

Equation 2-4

$$R_{eff} = \frac{(A_1 + A_2 .... + A_N)}{\left[\frac{A_1}{R_1} + \frac{A_2}{R_2} .... + \frac{A_N}{R_N}\right]}$$

Where:

R_{eff} = Area weighted effective R-value of duct system for use in calculating duct efficiency, (h-ft²-°F/Btu)

A_N = Area of duct segment n, square feet

R_n = R-value of duct segment n including film resistance, (duct insulation rated R + 0.7), (h-ft²-°F/Btu)

PROPOSED DESIGN

The software user inputs the R-value of the proposed duct insulation. The default duct thermal resistance shall be R-6.0.

STANDARD DESIGN

Package A required duct insulation R-values are used in the Standard Design.

VERIFICATION AND REPORTING

Credit for systems with mixed insulation levels or ducts buried in the attic require the diagnostic procedure in Reference Residential Appendix RA3.1.4.1

2.2.13.11 Buried Attic Ducts

Ducts partly or completely buried in blown attic insulation in dwelling units meeting the requirements for Verified Quality Insulation Installation may take credit for increased effective duct insulation.

The duct design shall identify the segments of the duct that meet the requirements for being buried, and these shall be separately input into the computer software. Ducts to be buried shall have a minimum of R-6.0 duct insulation prior to being buried. The computer software shall calculate the correct R-value based on the specified attic insulation R-value, insulation type, and duct size for ducts installed on the ceiling, and whether the installation meets the requirements for deeply buried ducts for duct segments buried in lowered areas of ceiling.

The portion of duct runs directly on or within 3.5 inches of the ceiling gypsum board and surrounded with blown attic insulation of R-30 or greater may take credit for increased effective duct insulation as shown in Table 2-12. Credit shall be allowed for buried ducts on the ceiling only in areas where the ceiling is level and there is at least 6 inches of space between the outer jacket of the installed duct and the roof sheathing above.

Duct segments deeply buried in lowered areas of ceiling and covered by at least 3.5 inches of insulation above the top of the duct insulation jacket may claim effective insulation of R-25 for fiberglass insulation and R-31 for cellulose insulation.

PROPOSED DESIGN

The software shall allow the user to specify buried ducts and provide the inputs to specify the details of the installation. The default is no buried ducts.

STANDARD DESIGN

The Standard Design has no buried ducts

VERIFICATION AND REPORTING

Correct installation of the duct system and attic insulation shall be certified by the installer and verified by a certified HERS rater (including that the requirements of Reference Residential Appendix RA3.5 and Reference Residential Appendix RA3.1 are met.

Table 2-14: Buried Duct Effective R-values

	Nominal Round Duct Diameter								
Attic Insulation	4''	5''	6''	7''	8''	10''	12''	14''	16''
	Effective Duct Insulation R-value for Blown Fiberglass Insulation								
R-30	R-13	R-13	R-13	R-9	R-9	R-4.2	R-4.2	R-4.2	R-4.2
R-38	R-25	R-25	R-25	R-13	R-13	R-9	R-9	R-4.2	R-4.2
R-40	R-25	R-25	R-25	R-25	R-13	R-13	R-9	R-9	R-4.2
R-43	R-25	R-25	R-25	R-25	R-25	R-13	R-9	R-9	R-4.2
R-49	R-25	R-25	R-25	R-25	R-25	R-25	R-13	R-13	R-9
R-60	R-25	R-25	R-25	R-25	R-25	R-25	R-25	R-25	R-13
	Effective Duct Insulation R-value for Blown Cellulose Insulation								
R-30	R-9	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2
R-38	R-15	R-15	R-9	R-9	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2
R-40	R-15	R-15	R-15	R-9	R-9	R-4.2	R-4.2	R-4.2	R-4.2
R-43	R-15	R-15	R-15	R-15	R-9	R-4.2	R-4.2	R-4.2	R-4.2
R-49	R-31	R-31	R-15	R-15	R-15	R-9	R-9	R-4.2	R-4.2
R-60	R-31	R-31	R-31	R-31	R-31	R-15	R-15	R-9	R-9

2.2.13.12 Duct/Air Handler Leakage

Duct/air handler leakage factors shown in Table 2-13 are used in simulating the duct system.

PROPOSED DESIGN

For each ducted system the software user specifies one of the duct/air handler leakage cases shown in Table 2-13.

STANDARD DESIGN

For ducted systems the Standard Design is sealed and tested duct systems in existing dwelling units or new duct systems.

VERIFICATION AND REPORTING

Sealed and tested duct systems require the diagnostic leakage test by the installer and verification by a HERS rater meeting the criteria described in Reference Residential Appendix RA3.

2.2.13.13 Low Leakage Air Handlers

PROPOSED DESIGN

Credit can be taken for installation of a factory sealed air handling unit tested by the manufacturer and certified to the Commission to have met the requirements for a Low Leakage Air-Handling Unit. Field verification of the air handler's model number is required.

STANDARD DESIGN

The Standard Design has a normal air handler.

VERIFICATION AND REPORTING

A Low Leakage Air Handler shall be reported on the compliance report and field verified in accordance with the procedures specified in Reference Residential Appendix RA3.1.4.3.9.

2.2.13.14 Verified Low Leakage Ducts in Conditioned Space

PROPOSED DESIGN

For ducted systems the user may specify that all ducts are entirely in conditioned space and the software will model the duct system with no leakage and no conduction losses.

STANDARD DESIGN

The Standard Design has ducts in the default location.

VERIFICATION AND REPORTING

Systems that have all ducts entirely in conditioned space shall be reported on the compliance documents and this shall be verified by measurements showing duct leakage to outside conditions is equal to or less than 25 cfm when measured in accordance with Reference Residential Appendix RA3.1.4.3.9.

Table 2-15: Duct/Air Handler Leakage Factors

Case	$a_s = a_r$
Untested duct systems in homes built prior to June 1, 2001	0.86
Untested duct systems in homes built after June 1, 2001	0.89
Sealed and tested duct systems in existing dwelling units	0.915
Sealed and tested new duct systems	0.96
Verified low leakage ducts in conditioned space	1.00
Low leakage air handlers in combination with sealed and tested new duct systems	0.97 or as measured

2.2.14 HVAC Systems

This section describes the general procedures for heating and cooling systems in low-rise residential buildings. The HVAC system includes the cooling system, the heating system, distribution system, and mechanical fans.

If multiple HVAC systems serve a building, each system and the conditioned space it serves may be modeled in detail separately or the systems may be aggregated together and modeled as one large system. If the systems are aggregated together they must be the same type and all meet the same minimum specifications.

2.2.14.1 Multiple System Types Within Dwelling

PROPOSED DESIGN

For Proposed Designs using more than one heating system type, equipment type or fuel type, and the types do not serve the same floor area, the user shall zone the building by system type.

STANDARD DESIGN

The Standard Design shall have the same zoning and heating system types as the Proposed Design.

VERIFICATION AND REPORTING

The heating system type of each zone is shown on the CF1

2.2.14.2 Multiple Systems Servings Same Area

If a space or a zone is served by more than one heating system, compliance shall be demonstrated with the most TDV energy-consuming system serving the space or the zone. For spaces or zones that are served by electric resistance heat in addition to other heating systems, the electric resistance heat shall be deemed to be the most TDV energy-consuming system unless the supplemental heating meets the Exception to §150.1(c)6). See eligibility criteria in Reference Residential Appendix RA-4 for installation requirements for exceptions.

For floor areas served by more than one cooling system, equipment, or fuel type, the system, equipment, and fuel type that satisfies the cooling load is modeled.

2.2.14.3 No Cooling

PROPOSED DESIGN

When the Proposed Design has no cooling system, the Proposed Design is required to model the Standard Design cooling system defined in Prescriptive Package A. Since the Proposed Design system is identical to the Standard Design system, there is no penalty or credit.

STANDARD DESIGN

The Standard Design system is the same as the Proposed Design.

VERIFICATION AND REPORTING

No cooling is reported on the CF1.

2.2.14.4 Zonal Control

With zonal control, the sleeping and living areas are modeled separately for heating, each with its own separate thermostat schedule and internal gain assumptions. The total non-closable opening area between zones cannot exceed 40 ft2. Other eligibility criteria for this measure are presented in the (Ref to be added).

PROPOSED DESIGN

The user selects zonal control as an HVAC system input.

STANDARD DESIGN

The Standard Design does not have Zonal Control.

VERIFICATION AND REPORTING

Zonal Control is a special feature reported on the CF1.

2.2.15 Cooling Ventilation System

Cooling ventilation systems operating at the dwelling unit level use fans to bring in outside air to cool the house when this can reduce cooling loads and save cooling energy. Cooling ventilation systems such as whole house fans involve window operation while systems such as NightBreeze use the HVAC duct system to distribute ventilation air. Cooling ventilation systems operate according to the schedule and setpoints shown in Table 2-18. Cooling ventilation systems that exhaust air through the attic require a a minimum of 1 ft2 of free attic ventilation area per 1000 CFM of rated capacity for relief; see Section 150.1(c)12 of the Standards.

Table 2-16: Cooling Ventilation Systems

Measure	Description	Inputs

Measure	Description	Inputs
Whole House Fan	Traditional whole house fan is mounted in the ceiling to blow house air into the attic inducing outdoor air in through open windows. Whole house fans are assumed to operate between dawn and 11 PM only at 25% of rated CFM to reflect manual operation of fan and windows by occupant. Fans must be listed in the California Energy Commission's Whole House Fan directory. If multiple fans are used, enter the total CFM.	Listed CFM from the CEC directory
Smartvent	Automatic operation of normal furnace fan and special damper to deliver outdoor air at cooling air flow through the HVAC duct system. Windows ventilation is disabled when this system is enabled.	
NightBreeze	Automatic operation by special controls of variable speed furnace fan and special damper to deliver outdoor air at optimized flow through the HVAC duct system. Windows ventilation is disabled when this system is enabled.	

Proposed Design

Software allows the user to specify whether a cooling ventilation system will be used, the type and any other required inputs. The default is a Whole House Fan meeting the prescriptive Package A requirements in of 2 CFM/ ft^2 of conditioned floor area in climate zones 8 to 14 and no cooling ventilation in other climate zones.

Standard Design

The Standard Design is a Whole House Fan meeting the prescriptive Package A requirements of 2 CFM/ ft^2 conditioned floor area in climate zones 8 to 14 and no cooling ventilation in other climate zones.

Verification and Reporting

A cooling ventilation system is a special feature.

2.2.16 Indoor Air Quality Ventilation

The Standards require mechanical ventilation that complies with ASHRAE Standard 62.2 to provide acceptable indoor air quality. ASHRAE Standard 62.2 provides several ways to comply with the requirement for mechanical ventilation and these are described in the compliance manual.

For the purposes of estimating the energy impact of this requirement in Compliance Software, the minimum ventilation rate is met either by a standalone IAQ fan system or a central air handler fan system that can introduce outdoor air. In many cases, this energy is substantially compliance neutral because the Standard Design is typically set equal to the Proposed Design.

The simplest IAQ fan system is an exhaust fan like a bathroom fan that meets the criteria in ASHRAE Standard 62.2 for air delivery and low noise. More advanced IAQ fan systems that have a supply or both supply and exhaust fans are also possible. To calculate the energy use of standalone IAQ fan systems, the systems are assumed to be on continuously.

To calculate the energy use of Central Fan Integrated Ventilation, the systems are assumed to be on for at least 20 minutes each hour as described below. The fan flow rate and fan power ratio may be different than the values used when the system is on to provide for heating or cooling depending on the design or controls on the IAQ ventilation portion of the system.

The minimum ventilation rate for continuous ventilation of each dwelling unit is given in Equation 2-5.

Equation 2-5

$$Q_{fan} = 0.01A_{floor} + 7.5(N_{br} + 1)$$

Where:

Q_{fan} = fan flow rate in cubic feet per minute (cfm),

A_{floor} = floor area in square feet (ft^2),

N_{br} = number of bedrooms; not to be less than one.

Table 2-17: Indoor Air Quality Ventilation Systems

System	Description	Inputs
Standalone IAQ Fan System	Dedicated fan system that provides indoor air quality ventilation to meet or exceed the requirements of ASHRAE Standard 62.2. Type is Exhaust, Supply or Balanced. If balanced, a heat recovery ventilator may be simulated by specifying the heat recovery efficiency.	Type, CFM, Heat Recovery Efficiency, Fan system to be used
Central Fan Integrated	Automatic operation of the normal furnace fan for IAQ ventilation purposes. Ventilation Type uses a special damper to induce outdoor IAQ ventilation air and distribute it through the HVAC duct system. Mixing type distributes and mixes IAQ ventilation air supplied by a separate Standalone IAQ Fan System.	Type, if Ventilation Type: CFM, Fan system to be used

PROPOSED DESIGN

The Proposed Design shall incorporate a mechanical ventilation system. This requirement is a mandatory measure. The Compliance Software allows the user to specify the IAQ ventilation system and type and the CFM of outdoor ventilation air which must be equal to or greater than what required by ASHRAE Standard 62.2. The default is a Standalone Exhaust system meeting Standard 62.2.

STANDARD DESIGN

The mechanical ventilation system in the Standard Design shall be the same as the Proposed Design. The air flow rate shall be equal to the Proposed Design. For standalone IAQ fan systems, the fan power ratio shall be equal to the Proposed Design value or 1.2 W/cfm, whichever is smaller. The sensible heat recovery effectiveness shall be 0. For central air handler fans, the fan power ratio is 0.58 W/cfm of central system airflow in ventilation mode.

VERIFICATION AND REPORTING

The required ventilation rate to comply with ASHRAE Standard 62.2 and the means to achieve compliance shall be indicated on the CF-1R. The IAQ system characteristics shall be reported in the *HERS Required Verification* listing on the CF-1R. The diagnostic testing procedures are in RA3.3.

Table 2-18: CF-1R Report – Indoor Air Quality

IAQ System Name	IAQ System Type	Airflow Rate (cfm)	Fan Power Ratio (W/cfm)

2.3 Conditioned Zones

The software requires the user to enter the characteristics of one or more conditioned zones. Subdividing dwelling units into conditioned zones for input convenience or increased accuracy is optional.

2.3.1.1 Conditioned Floor Area

The total conditioned floor area (CFA) is the raised floor, including interior floors, as well as the slab-on-grade floor area of the conditioned spaces. Stairwell floor area shall be included in conditioned floor area as the horizontal area of the stairs and landings between two floors of each story of the house.

PROPOSED DESIGN

The Compliance Software requires the user to enter the total conditioned floor area of each conditioned zone.

STANDARD DESIGN

The Standard Design building has the same conditioned zones as the Proposed Design.

VERIFICATION AND REPORTING

The conditioned floor area of each conditioned zone shall be reported on the CF-1R.

2.3.1.2 Conditioned Volume

PROPOSED DESIGN

The volume of the Proposed Design is the conditioned volume of air enclosed by the building envelope. The volume may be determined from the total conditioned floor area and the average ceiling height or from a direct user entry for volume.

STANDARD DESIGN

The volume of the Standard Design building is the same as the Proposed Design.

VERIFICATION AND REPORTING

2.3.1.3 Free Ventilation Area

Free ventilation area is the window area adjusted to account for bug screens, window framing and dividers, and other factors.

PROPOSED DESIGN

Free ventilation area for the Proposed Design is calculated by the software based on the types and areas of windows specified. The free ventilation area is modeled as 5 percent of the fenestration area for horizontal sliding windows, 10 percent of the fenestration area for operable windows, patio doors and French doors, and 0 for fixed windows. The total ventilation area is calculated from the areas of the three possible fenestration opening types, as shown in Equation 2-6 below:

Equation 2-6

$$Vent_{Area} = (Area_{Slider} \times 0.05) + (Area_{Hinged} \times 0.1) + (Area_{Fixed} \times 0.0)$$

STANDARD DESIGN

The Standard Design value for free ventilation area is 5 percent of the fenestration area (rough frame opening). This value assumes that all windows are opening type *Slider*.

VERIFICATION AND REPORTING

When a customized free ventilation area is entered (maximum 10 percent if all windows and skylights are hinged), this is reported in *Special Features* on the CF-1R.

2.3.1.4 Ventilation Height Difference

PROPOSED DESIGN

The default assumption for the Proposed Design is 2 feet for one-story buildings and 8 feet for two or more stories. Greater height differences may be used with special ventilation features such as high, operable clerestory windows. In this case, the user enters the vertical location of the openable part of the windows as the head height of the highest windows.

STANDARD DESIGN

The Standard Design modeling assumptions for the elevation difference between the inlet and the outlet is 2 feet for one story buildings and 8 feet for two or more stories.

VERIFICATION AND REPORTING

Any not defaulted window opening features shall be fully documented on the building plans and noted in the *Special Features* on the CF-1R.

2.3.1.5 Zone Elevations

The elevation of the top and bottom of each zone is required to set up the air flow network.

PROPOSED DESIGN

The user enters the height of the top surface the lowest floor of the zone relative to the ground outside as the "Bottom" of the zone. The user also enters the ceiling height, the floor to floor height (ceiling height plus the thickness of the intermediate floor structure) and the number of stories in the zone.

STANDARD DESIGN

The Standard Design has the same vertical zone dimensions as the proposed design.

VERIFICATION AND REPORTING

Vertical zone dimensions are shown on the CF-1R.

2.3.1.6 Mechanical Systems

PROPOSED DESIGN

The software requires the user to specify a previously defined HVAC System to provide heating and cooling for the zone and an IAQ Vent system to provide indoor air quality ventilation. The user may also specify a Cooling Ventilation System that applies to this and other conditioned zones.

STANDARD DESIGN

The software assigns standard design HVAC, IAQ Vent and Cooling Ventilation systems.

2.3.2 Cooling Ventilation

Natural ventilation is available during cooling mode when needed and available and there is venting shown in Table 2-18. The amount of natural ventilation used by computer software for natural cooling is the lesser of the maximum potential amount available and the amount needed to drive the interior zone temperature down to the natural cooling setpoint. When natural cooling is not needed or is unavailable no natural ventilation is used.

Computer software shall assume that natural cooling is needed when the building is in “cooling mode” and when the outside temperature is below the estimated zone temperature and the estimated zone temperature is above the natural cooling setpoint temperature. Only the amount of ventilation required to reduce the zone temperature down to the natural ventilation setpoint temperature is used and the natural ventilation setpoint temperature shall be constrained by the Compliance Software to be greater than the heating setpoint temperature

2.3.3 Conditioned Zone Assumptions

2.3.3.1 Internal Thermal mass

Internal mass objects are completely inside a zone so that they do not participate directly in heat flows to other zones or outside. They are connected to the zone radiantly and convectively and participate in the zone energy balance by passively storing and releasing heat as conditions change. Table 2-17 shows the standard interior Conditioned Zone Thermal Mass Objects and the calculation of the simulation inputs that represent them.

Table 2-19: Conditioned Zone Thermal Mass Objects

Item	Description	Simulation Object
Interior walls	The area of one side of the walls completely inside the conditioned zone is calculated as the conditioned floor area of the zone minus ½ of the area of interior walls adjacent to other conditioned zones. The interior wall is modeled as a construction with 25% 2x4 wood framing and sheetrock on both sides.	Wall exposed to the zone on both sides
Interior floors	The area of floors completely inside the conditioned zone is calculated as the difference between the CFA of the zone and the sum of the areas of zone exterior floors and interior floors over other zones. Interior floors are modeled as a surface inside the zone with a construction of carpet, wood decking, 2x12 framing at 16 in. o.c. with miscellaneous bridging, electrical and plumbing and a sheetrock ceiling below.	Floor/ceiling surface exposed to the zone on both sides
Furniture and heavy contents	Contents of the conditioned zone with significant heat storage capacity and delayed thermal response, for example heavy furniture, bottled drinks and canned goods, contents of dressers and enclosed cabinets. These are represented by a 2 in. thick slab of wood twice as large as the conditioned floor area, exposed to the room on both sides.	Horizontal wood slab exposed to the zone on both sides
Light and thin contents	Contents of the conditioned zone that have a large surface area compared to their weight, for example, clothing on hangers, curtains, pots and pans. These are assumed to be 2 BTU per square foot of conditioned floor area	Air heat capacity (Cair) = CFA * 2

PROPOSED DESIGN

The Proposed Design has Standard Conditioned Zone Thermal Mass Objects which are not user editable and are not a compliance variable. If the Proposed Design includes specific interior thermal mass elements that are significantly different from what is included in typical wood frame production housing, such as masonry partition walls, the user may include them.

STANDARD DESIGN

The Standard Design has Standard Conditioned Zone Thermal Mass Objects.

VERIFICATION AND REPORTING

Any user input interior thermal mass elements shall be fully documented on the building plans and noted in the *Special Features* on the CF-1R.

2.3.3.2 Thermostats and Schedules

Thermostat settings are shown in Table 2-18. The values for the "Whole House" apply to the Standard Design run and are the default for the Proposed Design run. See the explanation later in this section regarding the values for Zonal Control.

Table 2-20: Hourly Thermostat Set Points

Hour	Cooling	Venting	Heating	Zonal Control Heating	
			Single Zone	Living	Sleeping
1	78	Off	65	65	65
2	78	Off	65	65	65
3	78	Off	65	65	65
4	78	Off	65	65	65
5	78	Off	65	65	65
6	78	68*	65	65	65
7	78	68	65	65	65
8	83	68	68	68	68
9	83	68	68	68	68
10	83	68	68	68	65
11	83	68	68	68	65
12	83	68	68	68	65
13	83	68	68	68	65
14	82	68	68	68	65
15	81	68	68	68	65
16	80	68	68	68	65
17	79	68	68	68	68
18	78	68	68	68	68
19	78	68	68	68	68
20	78	68	68	68	68
21	78	68	68	68	68
22	78	68	68	68	68
23	78	68	68	68	68
24	78	Off	65	65	65

*Venting starts in the hour the sun comes up.

2.3.3.3 Determining Heating Mode vs. Cooling Mode

When the building is in the heating mode, the heating setpoints for each hour are set to the "Heating" values in Table 2-18, the cooling setpoint is a constant 78°F and the ventilation setpoint is set to a constant 77°F. When the building is in the cooling mode the heating setpoint is a constant 60°F, and the cooling and venting setpoints are set to the values in Table 2-18.

The mode is dependent upon the outdoor temperature averaged over hours 1 through 24 of day 8 through day 2 prior to the current day (e.g., if the current day is June 21, the mode is based on the average temperature for June 13 through 20). When this running average temperature is equal to or less than 60°F, the building is in a heating mode. When the running average is greater than 60°F, the building is in a cooling mode.

Setback Thermostat Exceptions: Certain types of heating and/or cooling equipment are exempt from the mandatory requirement for setback thermostats, including wall furnaces and through-the-wall heat pumps. If setback thermostats are not installed, then the Compliance Software shall model the

Proposed Design with the standard thermostat schedule, except that the heating mode setback set point shall be 66°F. In cases where setback thermostats are not mandatory but nonetheless are installed by the builder, the Compliance Software shall model the Proposed Design using the standard heating setback set point of 65°F. The Standard Design always assumes the setback schedule shown in Table 2-15.

2.3.4 Internal Gains

Internal gains are consistent with the HERS II specification:

> California Energy Commission, *HERS Technical Manual*, California Energy Commission, High Performance Buildings and Standards Development Office. CEC‐400‐2008‐012.

except for modifications to include latent gains. This section will be updated with all of the details,

Seasonal Adjustments

Daily internal gain shall be modified each month according to the multipliers shown in Table 2-20. These multipliers are derived from the number of daylight hours for each month. Identical inputs shall be used for both the Proposed Design and the Standard Design.

Table 2-21: Seasonal Internal Gain Multipliers

Month	Multiplier	Month	Multiplier	Month	Multiplier
Jan	1.19	May	0.84	Sep	0.98
Feb	1.11	Jun	0.80	Oct	1.07
Mar	1.02	Jul	0.82	Nov	1.16
Apr	0.93	Aug	0.88	Dec	1.21

2.3.5 Exterior Surfaces

The user enters exterior surfaces to define the envelope of the Proposed Design. The areas, construction assemblies, orientations, and tilts modeled shall be consistent with the actual building design and shall equal the overall roof/ceiling area with conditioned space on the inside and unconditioned space on the other side.

2.3.5.1 Ceilings below Attics

Ceilings below attics are horizontal surfaces between conditioned zones and attics. The area of the attic floor is determined by the total area of ceilings below attics defined in conditioned zones.

PROPOSED DESIGN

The software allows the user to define ceilings below attics and enter the area and select a construction assembly for each.

STANDARD DESIGN

The Standard Design has the same ceiling below attic area as the Proposed Design. The Standard Design ceiling is constructed with 2x4 framed trusses and insulated with the R-value specified in Package A.

VERIFICATION AND REPORTING

Ceiling below attic area and insulation are reported on the CF-1R.

2.3.5.2 Non-Attic (Cathedral) Ceiling and Roof

Non-Attic Ceilings, also known as cathedral ceilings, are surfaces with roofing on the outside and finished ceiling on the inside but without an attic space.

PROPOSED DESIGN

The software allows the user to define cathedral ceilings and enter the area and select a construction assembly for each. The user also enters the roof pitch and orientation of the surface.

STANDARD DESIGN

The non-attic ceiling/roof areas of the Standard Design building are equal to the non-attic ceiling/roof areas of the Proposed Design. The Standard Design roof and ceiling surfaces are assumed to be horizontal (no tilts). The Standard Design is modeled with the same construction assembly as the Proposed Design but with Package A insulation R-value. The aged reflectance and emittance of the Standard Design shall be determined by the Package A requirements.

VERIFICATION AND REPORTING

Non-attic ceiling/roof area and construction are reported on the CF-1R.

2.3.5.3 Exterior Walls

PROPOSED DESIGN

The software allows the user to define walls, enter the gross area and select a construction assembly for each. The user also enters the orientation and tilt of the wall.

The wall areas modeled shall be consistent with the actual building design and the total wall area shall be equal to the gross wall area with conditioned space on the inside and unconditioned space or exterior conditions on the other side. Walls adjacent to unconditioned spaces with no solar gains can be entered as a separate wall surface if the unconditioned space is not modeled as a zone.

STANDARD DESIGN

The gross exterior wall area in the Standard Design is equal to the gross exterior wall area of the Proposed Design. If the proposed wall area is framed wall, the gross exterior wall area of framed walls in the Standard Design (excluding knee walls) is equally divided between the four main compass points, north, east, south, and west. Window and door areas are subtracted from the gross wall area to determine the net wall area in each orientation. Walls adjacent to unconditioned space (garage walls) for all climate zones are wood framed, 2x4, 16-in. o.c., R-15 cavity insulation.

VERIFICATION AND REPORTING

Exterior wall area and construction are reported on the CF-1R.

2.3.5.4 Doors

PROPOSED DESIGN

The Compliance Software shall allow users to enter doors specifying the U-factor, area, and orientation. For doors with less than 50 percent glass area, the U-factor shall come from JA4, Table 4.5.1 (default U-factor 0.50). The glass area of the door, calculated as the sum of all glass surfaces plus two inches on all sides of the glass (to account for a frame), shall be modeled under the rules for fenestrations; the opaque area of the door shall be considered the total door area minus this calculated glass area. Doors with 50 percent or more glass area shall be modeled under the rules for fenestrations using the total area of the door.

STANDARD DESIGN

The Standard Design has 40 square feet of door area for each dwelling unit. All doors are assumed to face north and have a U-factor of 0.50. The net opaque wall area facing front is reduced by 40 ft^2 for each dwelling unit for the Standard Design.

VERIFICATION AND REPORTING

Door area and construction are reported on the CF-1R.

2.3.5.5 Fenestration

PROPOSED DESIGN

The Compliance Software shall allow users to enter individual fenestration or window types, the U-factor, SHGC, area, orientation, and tilt. Performance data (U-factors and SHGC) shall be NFRC values or taken from the California Energy Commission default tables. The default table for fenestration U-factors and SHGC, is included in §110.6 of the Standards. In spaces other than sunspaces, solar gains from windows or skylights use the CSE default solar gain targeting.

STANDARD DESIGN

If the Proposed Design fenestration area is less than 20 percent of the conditioned floor area, the Standard Design fenestration area is set equal to the Proposed Design fenestration area. Otherwise, the Standard Design fenestration area is set equal to 20 percent of the conditioned floor area. The Standard Design fenestration area is distributed equally between the four main compass points—north, east, south and west.

The Standard Design has no skylights.

The net wall area on each orientation is reduced by the fenestration area (and door area) on each facade. The U-factor and SHGC performance factors for the Standard Design are taken from the Package A specification. Where Package A has no requirement, the SHGC shall be set to 0.66.

VERIFICATION AND REPORTING

Fenestration area U-factor, SHGC, orientation, and tilt are reported on the CF-1R.

2.3.5.5.1 Overhangs and Sidefins

PROPOSED DESIGN

Software users enter a set of basic generic parameters for a description of an overhang and sidefin for each individual fenestration or window area entry. The basic parameters include *Fenestration Height, Overhang/Sidefin Length, and Overhang/Sidefin Height.* Compliance software user entries for overhangs may also include *Fenestration Width, Overhang Left Extension* and *Overhang Right Extension.* Compliance software user entries for sidefins may also include *Fin Left Extension* and *Fin Right Extension* for both left and right fins. Walls at right angles to windows may be modeled as sidefins.

Figure 2-5: Overhang Dimensions

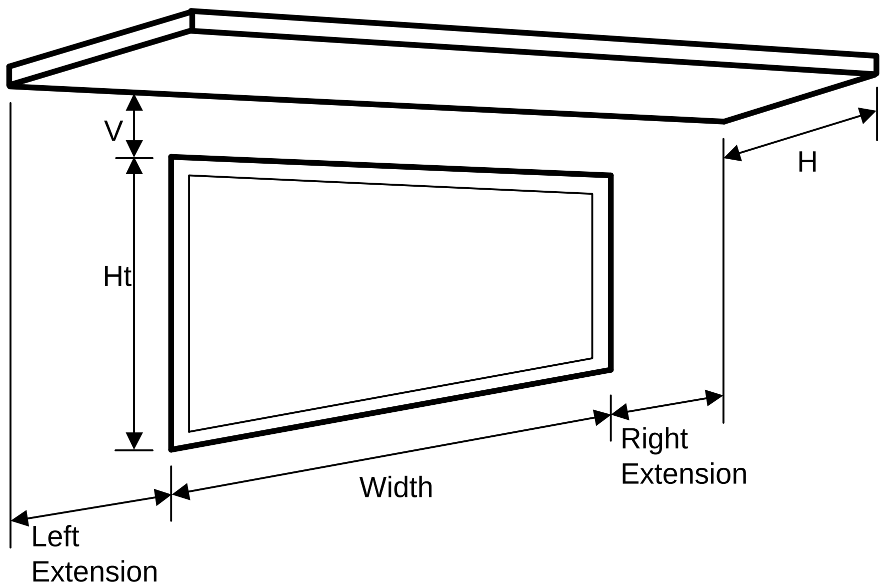
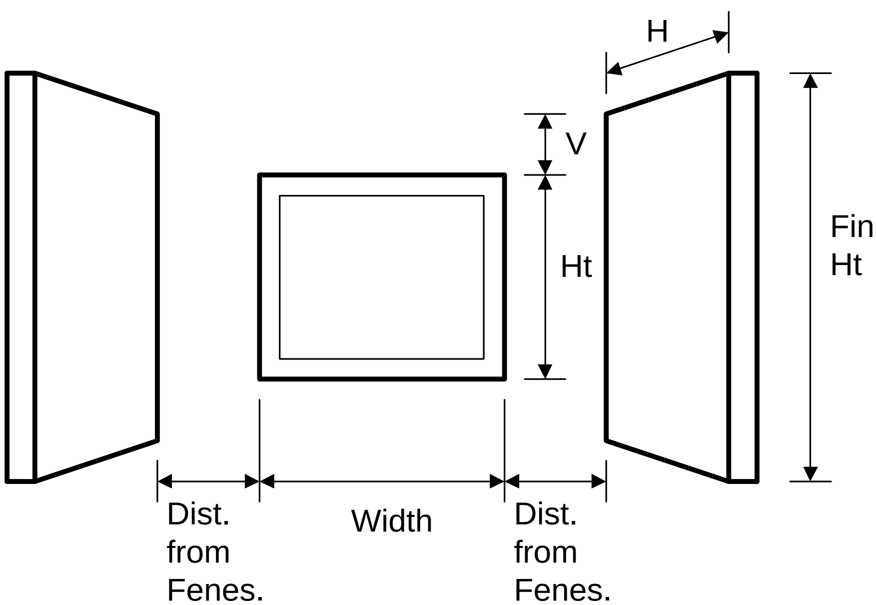


Figure 2-6: Side Fin Dimensions



STANDARD DESIGN

The Standard Design does not have overhangs or side fins.

VERIFICATION AND REPORTING

Overhang and fin dimensions are reported on the CF-1R.

2.3.5.5.2 Interior Shading Devices

For both the Proposed and Standard Design, all windows are assumed to have draperies and skylights are assumed to have no interior shading. Window medium drapes are closed at night and half open in the daytime hours. Interior shading is not a compliance variable and is not user editable.

2.3.5.5.3 Exterior Shading

For both the Proposed and Standard Design, all windows are assumed to have bug screens and skylights are assumed to have no exterior shading. Exterior shading is modeled as an additional glazing system layer using the ASHWAT calculation.

PROPOSED DESIGN

The Compliance Software shall require the user to either accept the default exterior shading device or select from a specific Commission-approved list of exterior shading devices for each fenestration element (see Table 2-21). The default choice for exterior shading device is *Standard,* which is bug screens.

STANDARD DESIGN

The Standard Design shall assume “Standard” which is bug screens.

VERIFICATION AND REPORTING

Other than standard exterior shading is a *Special Feature* reported on the CF-1R.

Table 2-22: Allowed Exterior Shading Devices and Recommended Descriptors

Recommended Descriptor	Exterior Shading Device Reference	Solar Heat Gain Coefficient
Standard	Bug Screen or No Window Shading	0.76
WvnScrn	Woven SunScreen (SC<0.35)	0.30
LvrScrn	Louvered Sunscreen	0.27
LSASnScrn	LSA Sunscreen	0.13
RlDwnAwng	Roll-down Awning	0.13
RlDwnBlnds	Roll -down Blinds or Slats	0.13
None (see Note 1)	For skylights only - No exterior shading	1.00

Note 1: None is the default for fenestration tilted less than 60 degrees from horizontal (skylights). None is not an exterior shading option for vertical windows.

2.3.5.6 Walls and Floors Between Zones

The user has the option of modeling unconditioned zones such as garages, crawl spaces. And basements.

PROPOSED DESIGN

The user inputs the area and construction of walls and floors between zones.

STANDARD DESIGN

The Standard Design shall have the same wall and floor areas and constructions meeting the prescriptive Package A.

VERIFICATION AND REPORTING

Areas and construction of interzone surfaces is reported on the CF1R.

2.3.5.7 Slab on grade floors

PROPOSED DESIGN

The software allows users to enter areas and exterior perimeter of slabs that are heated or unheated, covered or exposed slab, and with or without with slab edge insulation. The default condition for the Proposed Design is that 80 percent of each slab area is carpeted and 20 percent is exposed. Inputs of other than the default condition require that carpet and exposed slab conditions are documented on the construction plans. In climate zone 16, slab edges adjacent to garages and unconditioned spaces may be considered to be insulated with R-7 insulation to a depth of 16 inches (the prescriptive requirement).

STANDARD DESIGN

The Standard Design perimeter lengths and slab on grade areas are the same as the Proposed Design. Eighty percent of Standard Design slab area is carpeted and 20 percent is exposed. For the Standard Design, an unheated slab edge has no insulation with the exception of climate zone 16, which assumes R-7 to a depth of 16 inches.

VERIFICATION AND REPORTING

Slab areas, perimeter lengths and inputs of other than the default condition are reported on the CF-1R.

2.3.5.8 Raised Floors

PROPOSED DESIGN

The software allows the user to input floor areas and constructions for raised floors over a crawlspace, over exterior, over a controlled ventilation crawlspace, and raised concrete floors. The proposed floor areas shall be consistent with the actual building design.

STANDARD DESIGN

The Standard Design is the area and construction as the Proposed Design, except the insulation R-values meet the Package A requirements.

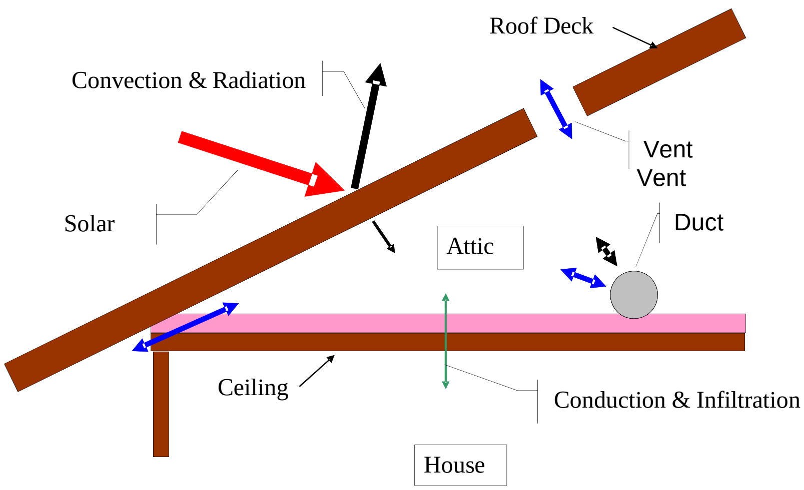
VERIFICATION AND REPORTING

Raised floor areas and constructions are reported on the CF-1R.

2.4 Attics

The Compliance Software models attics as a separate thermal zone and includes the interaction with the air distribution ducts, infiltration exchange between the attic and the house, the solar gains on the roof deck and other factors. These interactions are illustrated in Figure 2-7.

Figure 2-7: Attic Model Components



2.4.1 Ceiling Below Attic

Proposed Design

For each conditioned zone, the user enters the area and construction of each ceiling surface that is below an attic space. The Compliance Software shall allow a user to enter multiple ceiling constructions. Surfaces that tilt 60 degrees or more are treated as knee walls and are not included as ceilings. The sum of areas shall equal the overall ceiling area with conditioned space on the inside and unconditioned attic space on the other side.

The Compliance Software creates an attic zone whose floor area is equal to the sum of the areas of all of the user input ceilings below an attic in the building. The user specifies the framing and spacing, the materials of the frame path and the R-value of the insulation path for each ceiling construction.

The user inputs the proposed insulation R-value rounded to the nearest whole R. For simulation, all ceiling below attic insulation is assumed to have nominal properties of 2.6 R/inch, a density of 0.5 lb/ft^3 and a specific heat of 0.2 BTU/lb.

STANDARD DESIGN

The Standard Design shall have the same ceiling below attic area as the Proposed Design. The ceiling/framing construction shall be based on the Package A prescriptive requirement and standard framing is assumed to be 2x4 wood trusses at 24 in. on center.

VERIFICATION AND REPORTING

The ACM shall report the Area and Insulation R-value and layers of each construction.

2.4.2 Attic Roof Surface and Pitch

PROPOSED DESIGN

The roof pitch is the ratio of run to rise, e.g., 4:12 or 5:12. If the Proposed Design has more than one roof pitch, the pitch of the largest area shall be used.

The Compliance Software creates an attic zone roof. The roof area is calculated as the ceiling below attic area divided by the cosine of the roof slope where the roof slope is angle in degrees from the horizontal. The roof area is then divided into four equal sections with each section sloping in one of the cardinal directions (north, east, south and west). Gable walls, dormers or other exterior vertical surfaces that enclose the attic are ignored.

If the user specifies a roof with a pitch less than 2:12, the Compliance Software creates an attic with a flat roof that is 30 in. above the ceiling.

STANDARD DESIGN

The Standard Design shall have the same roof pitch, roof surface area and orientations as the Proposed Design.

VERIFICATION AND REPORTING

The roof pitch shall be reported.

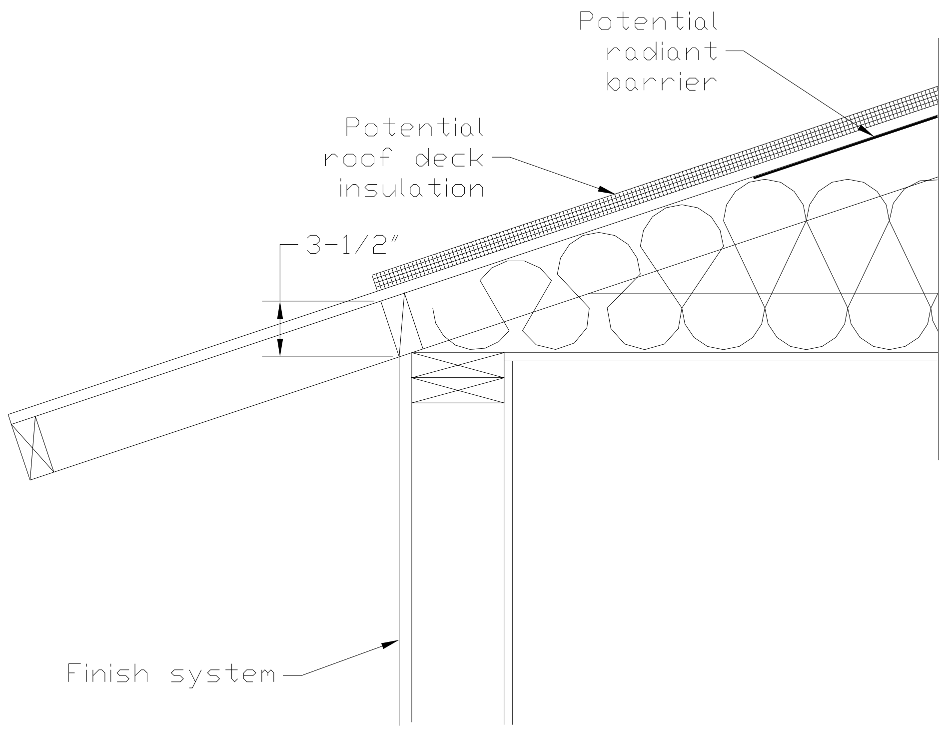
2.4.3 Attic Ventilation

Attic ventilation is not a compliance variable and is the same for both Proposed and Standard Design. The nominal ventilation area is 1 ft^2 for each 300 ft^2 of ceiling area (1/300) unless a whole house fan requires a larger vent area. In order to account for the effect of screens and other obstructions on attic ventilation, the free ventilation area is calculated as 0.5 x the nominal ventilation area.

2.4.4 Attic Edge

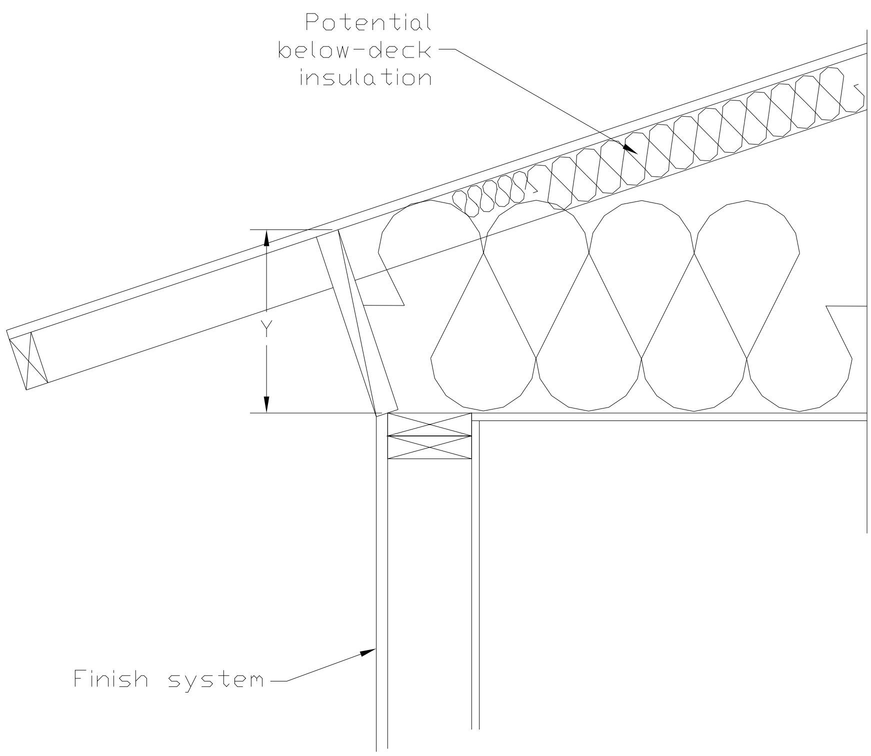
With a standard roof truss (Figure 2-8), the depth of the ceiling insulation is restricted to the space left between the roof deck and the wall top plate for the insulation path and the space between the bottom and top chord of the truss in the framing path. If the specified insulation completely fills this space, there is no attic air space at the edge of the roof. Heat flow through the ceiling in this attic edge area is directly to the outside both horizontally and vertically, instead of to the attic space. Measures that depend on an attic air space, such as radiant barriers or ventilation, do not affect the heat flows in the attic edge area.

Figure 2-8: Section at Attic Edge with Standard Truss



A raised heel truss (Figure 2-9) provides additional height at the attic edge that, depending on the height Y and the ceiling insulation R, can either reduce or eliminate the attic edge area and its thermal impact.

Figure 2-9: Section at Attic Edge with a Raised Heel Truss



For cases where the depth of insulation (including below deck insulation depth) is greater than the available height at the attic edge, the Compliance Software automatically creates cathedral ceiling surfaces to represent the attic edge area and adjusts the dimensions of the attic air space using the algorithms documented elsewhere. [Reference to the Algorithm Doc to be added.] If above deck insulation is specified it is included in the attic edge cathedral ceiling constructions, but radiant barriers below the roof deck are not.

PROPOSED DESIGN

The Compliance Software shall allow the user to specify that a raised heel truss will be used, with the default being a standard truss as shown in Figure 2-8. If the user elects a raised heel truss, the Compliance Software will require the user to specify the vertical distance between the wall top plate and the bottom of the roof deck (Y in Figure 2-9).

STANDARD DESIGN

The Standard Design shall have a standard truss with the default vertical distance of 3.5 in. between wall top plate and roof deck as shown in Figure 2-8.

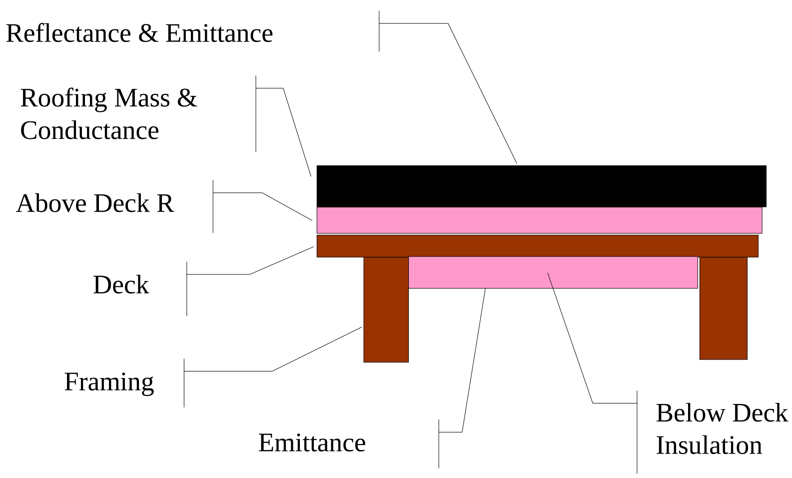
VERIFICATION AND REPORTING

A raised heel truss is a Special Feature and its vertical height above the top plate will be noted on the compliance documents and shall be labeled on the plans.

2.4.5 The Roof Deck

The roof deck is the construction at the top of the attic and includes the solar optic properties of the exterior surface, the roofing type, the framing, insulation, air gaps and other features. These are illustrated in Figure 2-10, which shows a detailed section through the roof deck.

Figure 2-10: Components of the Attic through Roof Deck



2.4.5.1 Roofing Type and Mass

PROPOSED DESIGN

The choice of roofing type determines the air gap characteristics between the roofing material and the deck, and establishes whether other inputs are needed, as described below. The choices for roof type are shown below.

- **Concrete or clay tile.** These have significant thermal mass and an air gap between the deck and the tiles.
- **Metal tile or wood shakes.** These are lightweight, but have an air gap between the tiles or shakes and the deck. Note that tapered cedar shingles do not qualify and are treated as a conventional roof surface.
- **Other high slope roofing types.** This includes asphalt and composite shingles and tapered cedar shingles. These products have no air gap between the shingles and the structural roof deck.
- **Low slope membranes.** These are basically flat roofs with a slope of 2:12 or less.

Above deck mass. The above deck mass depends on the roofing type. The mass is 10 lb/ft^2 for concrete and clay tile and 5 lb/ft^2 for metal tile, wood shakes or other high slope roofing types. For low slope roofs the additional thermal mass is assumed to be gravel or stone and the user chooses one of the following inputs that is less than or equal to the weight of the material being installed above the roof deck:

- No mass
- 5 lb/ft^2
- 10 lb/ft^2
- 15 lb/ft^2
- 25 lb/ft^2

STANDARD DESIGN

The roof type and slope shall match the Proposed Design.

VERIFICATION AND REPORTING

The roof type shall be reported as a Special Feature.

2.4.5.2 Solar Reflectance and Thermal Emittance

PROPOSED DESIGN

The Compliance Software shall allow the user to default the solar reflectance and thermal emittance of the roofing. The solar reflectance default is 0.08 for asphalt shingles or composition roof and 0.10 for all other roof types. The thermal emittance default is 0.85.

The Compliance Software shall allow the user to input aged solar reflectance and thermal emittance of roofing material that are rated by the Cool Roof Rating Council (CRRC). The installed value must be equal to or less than the value specified here. Roof construction with a roof membrane mass of at least 25 lb/ft^3 or roof area incorporated integrated solar collectors are assumed to meet the minimal solar reflectance.

STANDARD DESIGN

The solar reflectance and thermal emittance of the Standard Design roofing shall be as specified in the prescriptive Standards.

VERIFICATION AND REPORTING

CRRC Rated Roofing Products shall be reported as Special Features on the CF-1R.

2.4.5.3 Above Deck Insulation

Above deck insulation represents the insulation value of the air gap in “concrete or clay tile” or “metal tile or wood shakes.” The R-value of any user specified insulation layers between the roof deck and the roofing is added to the air gap value.

PROPOSED DESIGN

This input defaults to R= 0.85 for "concrete or clay tile" or for "metal tile or wood shakes" to represent the benefit of the air gap, but no additional insulation. The Compliance Software shall allow the user to specify the R-value of additional above deck insulation in any roof deck construction assembly.

STANDARD DESIGN

The Standard Design accounts for the air gap based on roofing type, but has no additional above deck insulation.

VERIFICATION AND REPORTING

Above deck insulation R-value is a Special Feature.

2.4.5.4 Below Deck Insulation

Below deck insulation is insulation that will be installed below the roof deck between the roof trusses or rafters.

PROPOSED DESIGN

The Compliance Software shall allow the user to specify the R-value of insulation that will be installed below the roof deck between the roof trusses or rafters. The default is no below deck roof insulation.

STANDARD DESIGN

The Standard Design has below deck insulation.

VERIFICATION AND REPORTING

The R-value of any below deck insulation is a Special Feature.

2.4.5.5 Roof Deck and Framing

The roof deck is the structural surface which supports the roofing. The Compliance Software assumes a standard wood deck and this is not a compliance variable. The size, spacing and material of the roof deck framing are compliance variables.

PROPOSED DESIGN

The roof deck shall be wood siding/sheathing/decking. The Compliance Software shall default the roof deck framing to 2x4 trusses at 24 in. o. c. The Compliance Software shall allow the user to specify alternative framing size, material and framing spacing.

STANDARD DESIGN

The Standard Design shall be 2x4 trusses at 24 in. o. c.

VERIFICATION AND REPORTING

Non-standard roof deck framing or spacing is a Special Feature.

2.4.5.6 Radiant Barrier

Radiant barriers are used to reduce heat flow at the bottom of the roof deck in the attic. A 0.05 emittance shall be modeled at the bottom surface of the roof deck if radiant barriers are used. If no radiant barrier is used, the value modeled is 0.9. If radiant barrier is installed over existing skip sheathing in a reroofing application, 0.5 is modeled.

PROPOSED DESIGN

The user shall specify whether or not the Proposed Design has a:

- Continuous Radiant Barrier
- Radiant Barrier over Discontinuous Sheathing
- No Radiant Barrier

STANDARD DESIGN

The Standard Design shall have a radiant barrier if required by the prescriptive Standards.

VERIFICATION AND REPORTING

Radiant barriers shall be reported as a Special Feature on the CF-1R.

2.5 Crawl Spaces

To be updated

2.6 Basements

To be updated

2.7 Garages

To be updated

2.8 Domestic Hot Water

To be updated

2.9 Additions/Alterations

To be updated

2.10 Documentation

To be updated